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**NASA**  
**TECHNOLOGY APPLICATIONS TEAM**  
**APPLICATIONS OF AEROSPACE TECHNOLOGY**

**ANNUAL REPORT**

**October 1992 - September 1993**

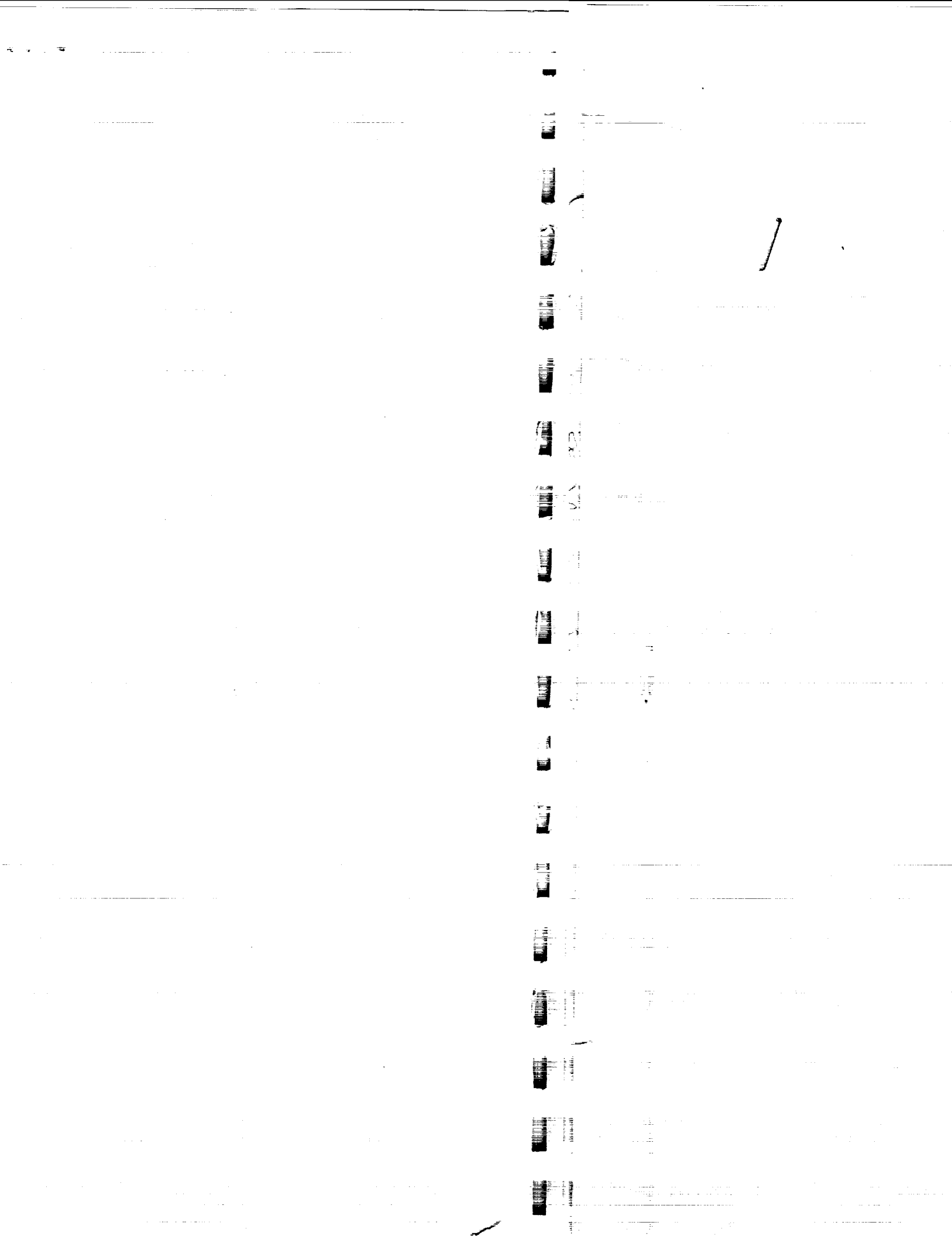
**for**

**National Aeronautics and Space Administration**  
**Office of Advanced Concepts and Technology**  
**Washington, DC 20546**

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Research Triangle Institute





**TECHNOLOGY APPLICATIONS TEAM**  
*APPLICATIONS OF AEROSPACE TECHNOLOGY*

**ANNUAL REPORT**

**October 1992 - September 1993**

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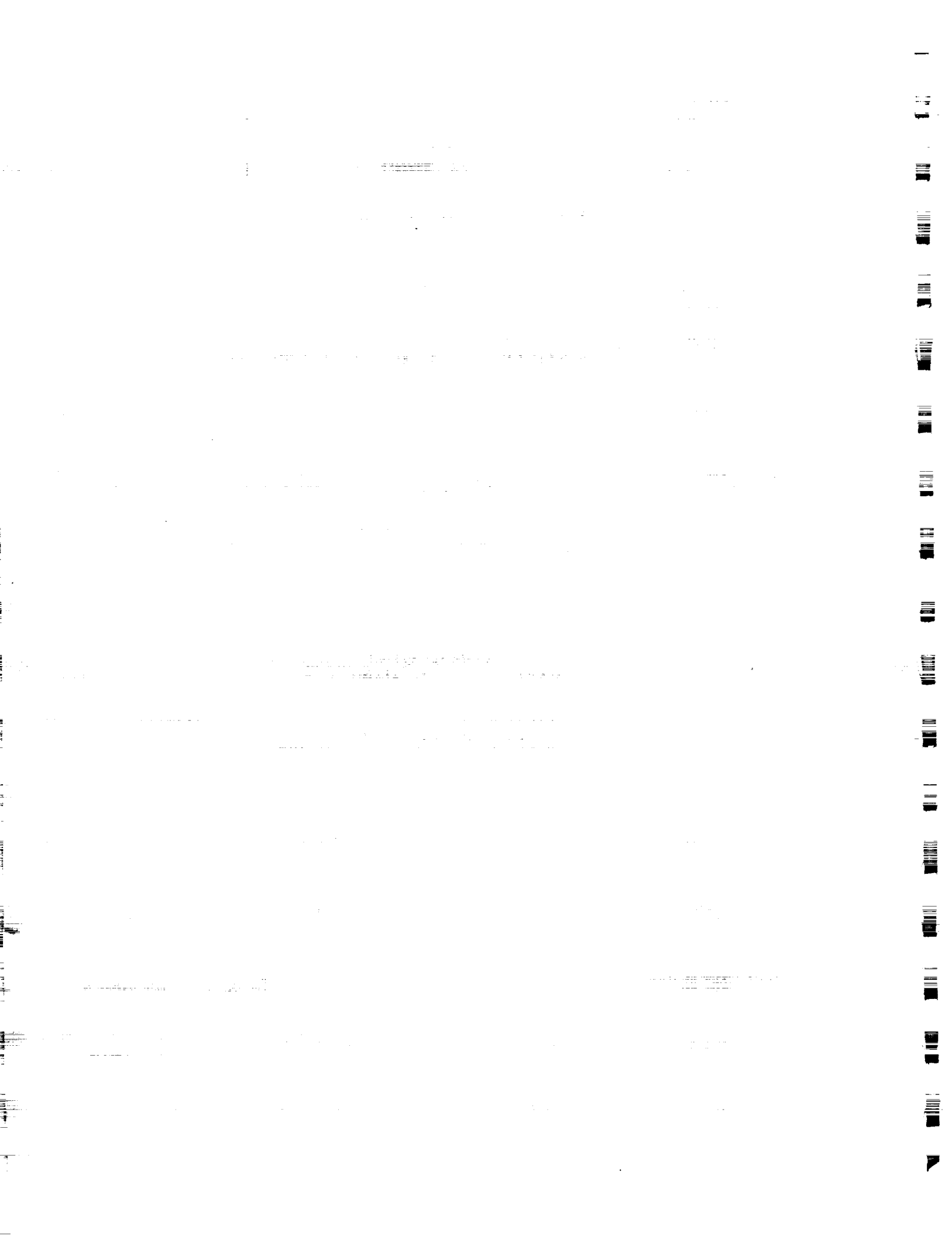
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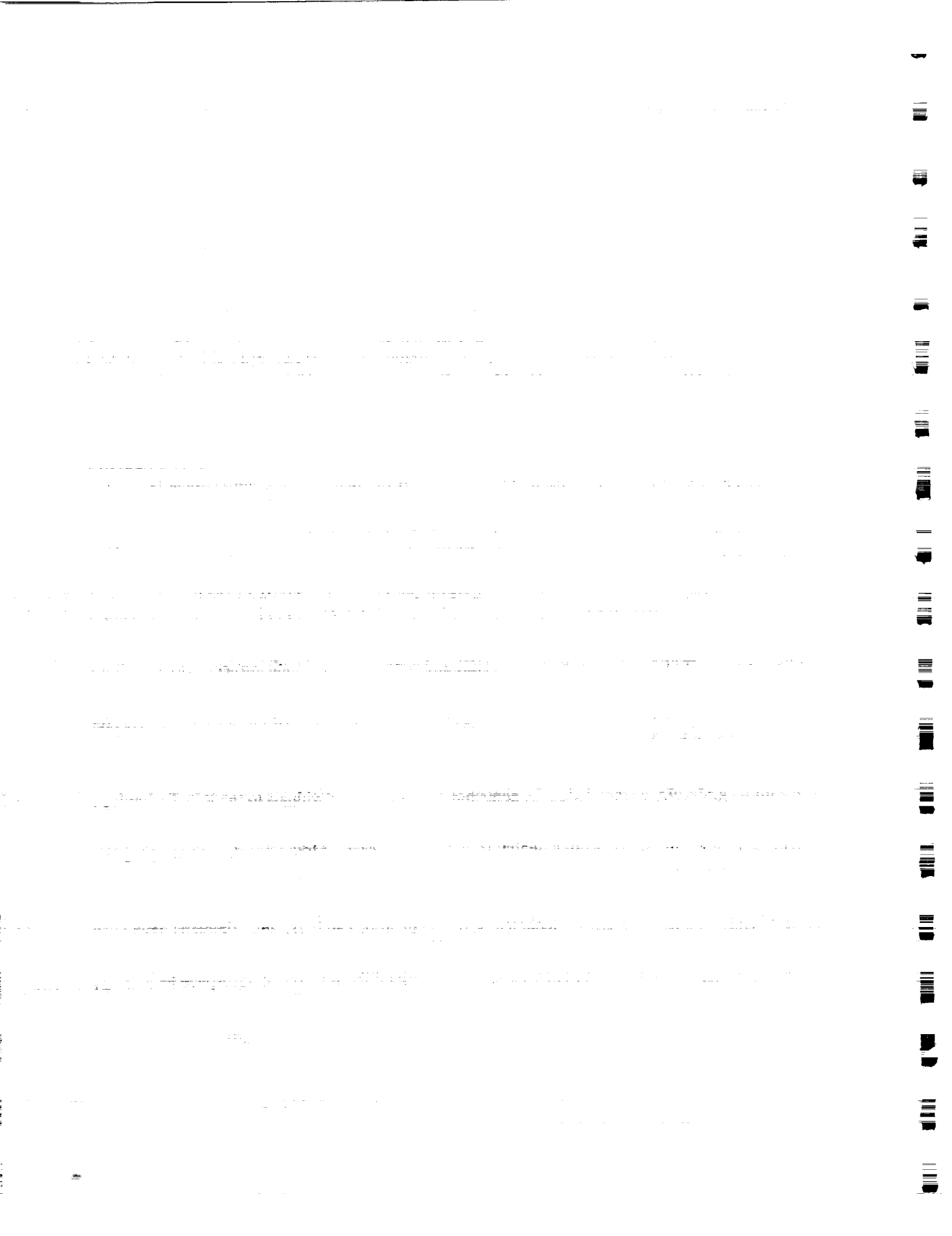
# INTRODUCTION

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This report covers the activities of the Research Triangle Institute (RTI) Technology Applications Team for the period 1 October 1992 through 30 September 1993. The work reported herein was supported by the National Aeronautics and Space Administration (NASA), Contract No. NASW-4367. Mr. Len Ault, NASA Headquarters, was the technical monitor. The work was performed in the RTI Center for Technology Applications under the direction of Dr. D. J. Rouse. Other participants in the program were Ms. Molly Dix, Mr. Dean Hering, Mr. Gary Hughes, Mr. Stephen Lehrman, Mr. Stephen Mangum, Mr. Daniel Winfield, Mr. Michael Hackett, Ms. Denise Maynard and Ms. Nancy Court. RTI consultants participating during the reporting period were Dr. Catherine Canada, Mr. Harry Watters and Mr. Jim Harrell.

Highlights of the RTI Applications Team activities over the past year are presented in Section 1.0. The Team's progress in fulfilling the requirements of the contract is summarized in Section 2.0. In addition to our market-driven approach to applications project development, RTI has placed increased effort on activities to commercialize technologies developed at NASA Centers. These Technology Commercialization efforts are summarized in Section 3.0. New problem statements prepared by the Team in the reporting period are presented in Section 4.0. The Team's transfer activities for ongoing projects with the NASA Centers are presented in Section 5.0. Section 6.0 summarizes the status of four add-on tasks. Travel for the reporting period is described in Section 7.0. The RTI Team staff and consultants and their project responsibilities are listed in Appendix A. Appendix B includes Technology Opportunity Announcements and Spinoff! Sheets prepared by the Team while Appendix C contains a series of technology transfer articles prepared by the Team.

The authors gratefully acknowledge the contributions of many individuals to the RTI Technology Applications Team program. The time and effort contributed by managers, engineers, and scientists throughout NASA were essential to program success. Most important to the program has been a productive working relationship with the NASA Field Center Technology Utilization (TU) Offices. The RTI Team continues to strive for improved effectiveness as a resource to these offices. Industry managers, technical staff, medical researchers, and clinicians have been cooperative and open in their participation. The RTI Team looks forward to continuing expansion of its interaction with U.S. industry to facilitate the transfer of aerospace technology to the private sector.



# EXECUTIVE SUMMARY

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The Research Triangle Institute is pleased to report the FY93 results of NASA contract NASW-4367, "Operation of a Technology Applications Team." Focusing on moving NASA technology into commercial use, the RTI Team has had a very successful year in commercialization and development of Space Act Agreements and licenses with industry.

Results in FY93 included the following:

**Three new commercial products** with applications in manufacturing and health care resulted from RTI-assisted projects in FY93, making a total eight new products over the past two years.

**Four joint development agreements with industry** resulted from RTI-assisted projects in FY93: three Space Act Agreements between NASA Field Centers and industry and one agreement between a NASA contractor and industry. Another agreement facilitated by RTI in FY93 is expected to be signed in the first quarter of FY94. All of the FY93 agreements involve dual use development of technology for both NASA mission goals and commercialization. Substantial industry funding of these projects accomplishes two objectives:

- leverages NASA mission funds, and
- establishes a strong industry commitment to commercialization.

**Three license agreements** with industry were signed in FY93 as a result of RTI-assisted projects. An additional license agreement is expected to be signed in early FY94.

**Innovative approaches and tools for proactive commercialization** were developed by RTI to facilitate effective and efficient transfer of NASA Field Center technology and patents.

## Commercialization

Commercialization is an integral component of all RTI technology transfer efforts. The success of this approach is reflected in the commercial products available in FY93 resulting from projects developed by the RTI Team as described below:

The **Capaciflector**, a NASA Goddard Space Flight Center technology, is in production by **Computer Application Systems, Inc. (CASI)** for commercial applications requiring proximity sensing. NASA GSFC will receive a 5% royalty on gross sales. Commercialization resulted from an RTI Technology Opportunity Announcement, a one page tool used by RTI to target industry and inform them of NASA technology with

## EXECUTIVE SUMMARY

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commercial potential. RTI prepared a Spinoff! sheet describing NASA's involvement for use by GSFC and CASI. RTI also assisted in the preparation of a NASA Spinoff magazine story.

An advanced **Multichannel Flow Cytometry System** has been developed by Ratcom, Inc. as a second generation spinoff of a dual-use flow cytometry development project involving NASA's Johnson Space Center, the American Cancer Society and Ratcom, Inc.. A multichannel system has been delivered to JSC for assessment for use on Space Station, and Ratcom will market the clinical unit internationally. RTI originally identified the mutual interest of JSC and ACS and conducted a national workshop to define the scope of the project.

**Diagnostic Ultrasound Corporation** commercialized the **Bladderscan™** for monitoring bladder fullness and alerting the user or caregiver for management of urinary incontinence. Central monitoring systems are planned for use in long term care settings, so nurses can intervene on a timely basis. This product incorporates NASA LaRC ultrasound technology licensed by Diagnostic Ultrasound Corporation. RTI initiated this project through discussion with the Association for Retarded Citizens (ARC) and the National Institute on Disability and Rehabilitation Research. RTI identified the technology at LaRC, assisted in the development of the project plan and cofunding, identified industry partners and assisted in the preparation of a 1993 NASA Spinoff magazine story.

### Agreements

Agreements with industry partners are an important tool for establishing cooperative projects. In FY93, RTI has been very active in developing agreements and facilitating a timely negotiation and approval process. RTI's accomplishments in the development of both Space Act and licensing agreements in FY93 are:

The **National Center for Manufacturing Sciences (NCMS)** and NASA Langley are in final negotiations for a reimbursable **Space Act Agreement** to fund the development of **Optically Stimulated Electron Emission for inspecting the cleanliness of printed circuit boards**. This dual-use project will develop the technology for both industry inspection of circuit boards and NASA inspection of critical weld surfaces of the solid rocket motors. RTI worked with NCMS to identify the industry requirement and with Marshall Space Flight Center and Langley Research Center to identify the NASA requirement and nondestructive testing technology. RTI assisted the Langley Technology Utilization Office in development of the project plan and Space Act Agreement.

RTI facilitated negotiations that led to the signing of a **Space Act Agreement** for the **Contextual Alarm Management System (CALMS)** between a corporate partner and Johnson Space Center. This dual-use project will develop technology both for medical monitoring of astronauts and for improved medical monitoring during surgery and in special education classrooms. RTI identified the technology need with a national panel of special education experts, identified the JSC technology and mission requirement, identified an interested industry partner, and facilitated the development of the project plan and Space Act Agreement.

**Healthdyne Technologies, Inc.** and the University of Central Florida have signed a research contract and license agreement that will allow the **Medical Oxygen Concentrator Project** to move forward with Kennedy Space Center. Under the agreement, Healthdyne will fund all of the remaining Phase II plan in exchange for exclusive rights to medical use. Healthdyne's involvement in this project resulted from an RTI Technology Opportunity Announcement and discussions with industry.

After a Technology Briefing at Kennedy Space Center(organized by RTI) **Red Pepper Software** has secured a software license from Kennedy Space Center for the **Ground Processing Scheduling System (GPSS)**. This artificial intelligence-based software was developed to handle the massive scheduling task of preparing shuttle orbiters for their next missions. Red Pepper also reports that they are close to an agreement to provide the software and services to one of the attendee companies at the KSC Technology Briefing.

A **Space Act Agreement for the Ice Detection and Thickness Measurement** project between Raton Technology Research (RTR)-- formerly Stolar/RIMTech, and Johnson Space Center was initiated in September 1993. RTI supported this commercialization effort by contacting FAA and industry to review the technology. Through this technology, NASA and RTR will be helping to meet a major FAA concern-- detecting ice on aircraft to prevent accidents.

ABB Amdata has signed a license agreement to commercialize the convolver for real-time information and signal processing (CRISP) technology from NASA Langley. Also, a similar license agreement with Westdyn is awaiting final signature. Both companies learned of this technology at an RTI-assisted commercialization workshop at NASA Langley, and both are negotiating joint development agreements with NASA Langley for further development.

## EXECUTIVE SUMMARY

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### **Innovative Approaches to Technology Transfer**

RTI's success in commercializing NASA technology to meet important needs of U.S. industry and health care is reflected in the new products and agreements developed in FY93. To improve the RTI Team's effectiveness and to respond to conditions and trends in industry and NASA, RTI continues to develop innovative approaches for technology transfer. Some examples of RTI activities in FY93 to refine current techniques and develop new approaches are:

To improve effectiveness in marketing NASA technologies, RTI conducted a study of **best practices for assessment and marketing of technology**, consulting the available literature as well as successful licensing programs at MIT, University of Chicago/Argonne National Lab, and the University of California system. In addition, RTI consulted 30 large and small companies to determine the format and content they would prefer to see in initial information packages presenting a NASA technology available for licensing and/or joint development. RTI incorporated the results of these studies in its approach for marketing NASA technologies and preparing Technology Opportunity Announcements for distribution to industry.

To provide closer linkage between RTI Team activities and NASA technology development programs, RTI initiated technology commercialization efforts with:

**the NASA Operations Intercenter Work Group** - at the request of Mel Montemerlo, NASA HQ Code C, and Peter Friedland, NASA Ames, RTI will market selected intelligent data analysis technologies.

**NASA Code R** - RTI will work with Code R and Code R supported Centers to pursue secondary applications of aeronautics technologies.

**NASA Life Sciences** - RTI will assist Life Sciences both in technology commercialization and in development of joint projects with the National Institutes of Health.

RTI developed a **TechTracs database system for tracking new technology reports, patents and licenses**. Designed by the Kennedy Space Center Patent and Technology Utilization offices, TechTracs automates routine correspondence and metrics calculations and provides a unified database that reduces redundant data entry required in the past. NASA has made a commitment to install TechTracs in all HQ and Field Center Patent and Technology Transfer Offices. This system has the potential of providing the NASA Technology Transfer Network with information on NASA technologies as soon as they are available for licensing.



# 1.0 HIGHLIGHTS

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## Projects

- The Applications Team worked with the Langley Technology Utilization Office to develop an agreement between the **National Center for Manufacturing Sciences (NCMS)** and NASA to fund the development of **Optically Stimulated Electron Emission for inspecting the cleanliness of circuit boards**. NCMS has agreed to provide Langley \$40,000 to support this investigation. As a result of the interest by industry, NASA Langley has filed a patent application. This dual-use technology will be used by Marshall Space Flight Center to inspect critical welding surfaces of solid rocket motors (p. 101).
- After the Technology Briefing at Kennedy Space Center (organized by RTI) **Red Pepper Software** has secured a software license from the Kennedy Space Center for the **Ground Processing Scheduling System (GPSS)**. This artificial intelligence based software was developed to handle the massive scheduling task for preparing shuttle orbiters for their next missions. Red Pepper also reports that they are close to an agreement to provide the software and services to one of the attendee companies at the December, 1992 Technology Briefing (p. 20).
- RTI organized and chaired the May 19-20, 1993 **NCI-NASA Workshop on Digital Mammography Technologies** in Bethesda, MD. The meeting was a huge success with over 90 persons attending, including 28 medical imaging industry representatives. Subsequently, NASA and the National Cancer Institute agreed to issue a joint Program Announcement soliciting proposals for Federal technology transfer to digital mammography. NASA technologies at JPL, ARC and LaRC offer promising solutions (p. 89).
- A **Space Act Agreement for the Ice Detection and Thickness Measurement** project between **Raton Technology Research (RTR)** - formerly Stolar/RIMTech, and Johnson Space Center was initiated in September 1993. The technology, called **KELVIN**, is receiving significant attention in the aircraft and ground transportation industries. Currently, RTR is developing market positions, and working on design specifications, display concepts, design of the antenna, and planning for initial testing (p. 97).
- RTI facilitated negotiations for the **Contextual Alarm Management System (CALMS)** Space Act Agreement which was signed by the corporate partner and JSC. RTI led a kick-off meeting at Johnson Space Center for the CALMS project which will be a dual-use technology development, providing benefits to the Nation's hospitals, to special education classrooms, as well as to manned NASA missions (p. 85).

## 1.0 HIGHLIGHTS

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- **Healthdyne Technologies, Inc.** and the Univ. of Central Florida have signed a research contract and license agreement that will allow the **medical oxygen concentrator project** to move forward with Kennedy Space Center. Under this agreement, Healthdyne will fund all of the remaining phase II plan in exchange for exclusive rights to medical use. Healthdyne's involvement in this project resulted from an RTI Technology Opportunity Announcement (p. 103).
- RTI participated in a meeting at **IVAC Corporation** to discuss the application of the **Stennis Space Center predictive response algorithm** to IVAC's electronic thermometer. IVAC was identified as a potential partner by way of an RTI-developed Technology Opportunity Announcement. The meeting resulted in a phase I project plan to develop a proof-of-concept product. Both NASA and IVAC are confident that the Space Act Agreement will be signed by December 1993 and that the project will proceed (p. 115).
- Using an RTI-developed Technology Opportunity Announcement to contact targeted companies, RTI obtained commercial interest in the **Ames Modular Sensor Conditioning System**. RTI organized and participated in meetings with potential commercialization partners at Ames Research Center to demonstrate and discuss the system. Currently Ames is working with Motorola to develop a data module based on the system. A major medical monitoring company is participating in the specification development by providing commercial specifications (p. 81).
- The Applications Team worked with the Langley Technology Utilization Office to conduct a **commercialization workshop for the Powder Curtain Prepreg Technology**. The Applications Team researched the technology and its markets, identified and contacted companies that would be interested in the technology, and prepared the invitation brochure announcing the workshop. Two companies that attended the June, 1993 workshop continue to express interest in licensing the patent or engaging in further cooperative development of the technology (p. 28, 105).
- **ABB Amdata and Westdyn Systems, Inc.** are developing **Joint Development Agreements** with Langley Research Center to commercialize the CRISP technology. CRISP is an advanced technique for processing data which has applications in aerospace, nuclear, and utility industries. ABB Amdata has been granted a license, and a license with Westdyn is pending final signature. These collaborations resulted from the commercialization workshop that RTI assisted LaRC in conducting last May (p. 87).
- The **Capaciflector**, a NASA Goddard Space Flight Center technology, is in fabrication by **Computer Application Systems, Inc. (CASI)** for commercial applications. NASA GSFC will receive a 5% royalty on gross sales. Commercialization resulted from an RTI

Technology Opportunity Announcement, a one page tool used by RTI to target industry and inform them of NASA technology with commercial potential.

- The RTI Team conducted two telephone conference calls between **Laureate Learning Systems** and the JSC Software Technology Branch to determine the **Early Language Intervention System (ELIS)** project status and to facilitate communication between the two groups. At RTI's suggestion, Mr. Bob Way of JSC visited Laureate to work with them on the graphics interface (p. 93).
- The Johns Hopkins University was awarded a **Technology Transfer Award** at Technology 2002 for the **Low Vision Enhancement System** developed with Stennis Space Center. This project was established by RTI following an RTI-organized workshop on Low Vision and Aging .
- RTI supported NASA Langley's technology-push efforts on the technique for **absolute measurement of ultrasonic displacement amplitude**. Specific assistance included developing a Technology Opportunity Announcement, identifying and contacting over 40 potential commercial partners, and organizing and inviting interested companies to a commercialization workshop. The workshop is planned for October at Langley, in conjunction with Langley Technology Opportunity Showcase (p. 83).
- RTI organized a meeting at the **National Eye Institute (NEI)**, Bethesda, MD, between scientists from NEI and NASA Lewis Research Center to discuss NEI evaluation of the NASA Lewis-developed **Fiber Optic Probe for Cataract Detection** in controlled clinical trials funded by NEI. The NEI indicated interest in supporting clinical studies once the full clinical prototype is developed and initial testing complete. As a result of an RTI-developed Technology Opportunity Announcement, Woodlyn Corp. and Meridian Medical Lasers have expressed interest in the fiber optic cataract probe at Lewis Research Center. RTI is assessing the interest and potential of these two entities as possible corporate partners (p. 24).
- The Technology Application Team assisted with the Kennedy Space Center workshop on **protective coatings for metal with conducting polymers**, held in October 1992. This effort resulted in the first **Cooperative Research and Development Agreement (CRADA)** involving both NASA and the Department of Energy since the Memorandum of Understanding was executed between the two agencies in July 1992 (p. 26).
- The Technology Applications Team has been working with the **Air Conditioning and Research Institute (ARI)**, to identify appropriate NASA technology to solve industry-wide

## 1.0 HIGHLIGHTS

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problems. RTI organized a **commercialization workshop for JPL's Advanced Regenerative Adsorption Cooling technology**. Industry participation was coordinated through the Air Conditioning and Refrigeration Institute. Forty-two individuals attended representing equipment manufacturers, gas utilities, industry consortia and associations, DoE, SDIO, and NASA. As a result of the workshop a relationship was formed between JPL, Aerojet and Lennox (p. 27).

- RTI established new initiatives with the **National Food Processors Association**. Fifteen responses were received for the first problem statement, which dealt with **non-destructively testing food packages** (p.37). In addition to NASA, responses were received from NIH, USAF, USDA, DOE. A solution to the problem would reduce public health hazards from contaminated foods. The second problem statement that dealt with **sterilization of food particles flowing through a pipe** generated thirty-five responses with several from NASA researchers. Three of the top four proposals reviewed originated at NASA facilities (p. 47).
- The Team assisted in the technology commercialization efforts at Langley Research Center for the **self-nulling eddy-current probe (Simpson Probe)**. Specifically, RTI completed a market assessment, identified potential commercialization partners, prepared a brochure outlining the technology, and invited target companies to a Commercialization Workshop at Langley. The workshop is to be held in conjunction with the Technology Opportunity Showcase in October (p. 28).
- The RTI Team prepared a **Technology Opportunity Announcement (Appendix B) for the Virtual Visual Environment Display (VIVED)** from Johnson Space Center. The TOA was sent to JSC for use at a conference June 26 and mailed to a list of target companies. RTI arranged an invitation for the VIVED project staff to present this technology at the combined annual meeting of the Association for Educational Communications and Technology (AECT) and the Association for the Development of Computer-based Instructional Systems (ADCIS) (p. 25).
- The Applications Team worked with the Stennis Technology Utilization Office to perform a market analysis for the **gamma ray collimator**. The Team researched the market for the instrument and identified and contacted companies manufacturing similar equipment. One of these companies contacted the Marshall Space Flight Center legal counsel requesting information regarding licensing the patent. The company has submitted to NASA the required background information and has met at Stennis with the gamma ray collimator inventor and TU Office (p. 29, 79).
- The problem statement on **joining technologies for composite materials** was distributed to over 200 Federal labs and the NASA Field Centers. The Center for Composite Materials

(CCM) selected two responses for further investigation. RTI organized telephone conference calls with the CCM and the two laboratories: Advanced Systems Concepts Office, U.S. Army Armament Research, Development and Engineering Center, and the Naval Surface Warfare Center. The CCM will carry on with both facilities to try to put together collaborative ventures (p. 33).

- RTI met with the Kennedy Space Center TUO and the Florida Institute of Technology (FIT) to develop a plan for securing a commercial partner for the **Bioluminescence Assay of Mycobacterium in AIDS** patients. Several intellectual property issues were identified and were to be resolved by the FIT before full commercialization activities begin.

## **Outreach**

- The Applications Team worked with the Goddard Technology Utilization Office to hold the first **Photonics Commercialization Workshop** in March, 1993. Over twenty-five organizations attended the workshop and heard presentations on nine Goddard photonics technologies and two Goddard-funded SBIR projects. The Applications Team arranged for national publicity for the workshop and developed the mailing list of invited companies. Team activities were coordinated with the Goddard TU Office, the New England RTTC, and the Mid-Atlantic RTTC (p. 27).
- Doris Rouse chaired a session on **Technology Transfer at the 30th Space Congress** and presented a paper entitled "Dividends from Space: How NASA Technology has Provided a Competitive Advantage for Industry." More than 100 representatives from NASA, industry and the public attended the session.
- RTI gave a presentation to the **47th National Conference on the Advancement of Research**, Oct. 3-6, 1993. Presentation covered the Technology Applications Team's activities in developing technology transfer projects to address critical industry needs.
- RTI gave a presentation to the **Combined Southeast Region FLC/RTTC** meeting in Research Triangle Park. The presentation covered technology transfer activities at RTI and the results of the RTI/FLC Pilot Project.
- During the year, RTI placed increased emphasis on identifying and transferring environmental management technologies. Priority technology needs were sought through contacts at the **U.S. Environmental Protection Agency** and several industry associations such as the **Hazardous Materials Control Resources Institute** and the **Air & Waste Management**

## 1.0 HIGHLIGHTS

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**Association.** Meetings were held with these groups as well as the **National Environmental Technology Applications Corporation.**

- The RTI Team wrote three articles on **Technology Transfer** which were published by the **Hazardous Materials Control Resources Institute (HMCRI)** for their July, September, and November 1993 issues of their *Focus* newsletter. These articles which included references to the many NASA technology transfer channels, are included in Appendix C. This series of articles was requested by the Director of the HMCRI to inform their membership (over 5,000) about the opportunities and process for accessing NASA and other Federal lab technologies.
- RTI represented NASA at a meeting with the **Equipment Manufacturers Institute (EMI)** in Washington, DC. The meeting, sponsored by the USDA, had participants from numerous federal agencies. The EMI is looking for federal technologies that can solve agricultural problems, including safety. EMI has generated problem statements (based on the RTI developed format). RTI is managing the distribution, collection, and review of NASA proposed solutions (p. 49, 55, 61, 67, 71, 75).
- RTI has participated in meetings of the **American Society of Mechanical Engineers (ASME) National Laboratories Technology Transfer Committee (NL TTC)** which consists of Deputy Directors of eleven DoE National Labs and the Deputy Director of NIST. NASA and the Environmental Protection Agency have been invited to become members. The NL TTC is revising its mission to work with industry associations to define industry-wide problems, present these problems to federal scientists and engineers, and match solutions to the needs. The Applications Team, representing NASA, is working with the NL TTC to accomplish this agenda.
- The Applications Team arranged for an article by NASA to be published in *ASME News*. The Applications Team helped the NASA Lewis Research Center **Computational Materials Laboratory** write an article titled *Computerized Experiments are Final Frontier as US Seeks First Place in Technology Race* published in the August, 1993 issue of *ASME News*. The article publicizes the materials modeling being conducted by the Computational Materials Laboratory and offers the laboratory as a resource to industry.
- RTI attended the Fall and Spring **Federal Laboratory Consortium** semi-annual meetings. At the Fall meeting, RTI gave a presentation on technology commercialization including a status report on the **FLC/RTI demonstration project**.
- As a result of our discussions with Robert (Bob) Ackerman (Senior Editor, *SIGNAL Magazine*, AFCEA's international journal), an article was featured in the April edition

of **SIGNAL Magazine** describing NASA's Technology Transfer Program and RTI's work with NASA. RTI made the initial contact with Mr. Ackerman, provided him with information on how we work with NASA, and referred him to appropriate officials at NASA HQ for overall program information.

- RTI met with Mr. Rob Busacca of **Pepsi Cola International** to discuss the problem statements being developed with the **National Soft Drink Manufacturers Association**. Two industry-wide problems were selected for development: (1) rapid measurement of carbon dioxide purity and (2) water treatment for post-mix equipment.
- RTI met with Stephen Gomes and Paul Masson from **The American Technology Initiative (Amtech)** on two separate occasions to explore approaches for closer RTI/AMTECH collaboration in support of NASA's technology transfer objectives.
- RTI's **Technology Opportunity Announcement** survey, begun in the previous fiscal year, was completed and documented in a report. The results are being used by the Applications Team to create more effective means of conveying technology opportunities to the industry managers who review this type of information.
- The RTI TAT had several discussions with **McDonnell Douglas Aircraft Corporation** covering a number of technical issues. An area of common interest is the transfer of technologies from NASA to the aerospace industry.
- RTI supported NASA HQ with a Technology Transfer Exhibit, including STARS kiosk, at the **4th Computing Conference and Exposition of AFCEA**.

### ***Technology Spinoff! Sheets***

In a continued effort to inform the public of successful spinoffs from NASA technologies RTI used the previously developed *Spinoff!* Sheet format to describe the wireless infrared communications technology commercialized by Wilton Industries, a division of K&M Electronics, Inc. Spinoff sheets developed by RTI were used at the Technology 2002 Conference. More recently, RTI developed two *Spinoff!* sheets. The first describes Goddard Space Flight Center's **Capaciflector** spinoff success with transfer to **Computer Application Systems, Inc.** The second sheet was developed at the request of Marshall Space Flight Center describing the **Ocular Screening System** developed and commercialized by MSFC and **Vision Research Corporation**. Copies of *Spinoff!* sheets developed in this FY are included in Appendix B.

## 1.0 HIGHLIGHTS

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### *Field Center Summaries*

In response to a request from NASA HQ, RTI collected and summarized information describing selected areas of expertise at four of the nine NASA Field Centers: ARC, GSFC, LaRC, LeRC. The goal of the information is to provide resources that enable targeted presentations to industry. Viewgraphs and background information, including identification of spinoffs from the selected technical areas were provided to HQ.

### *RTTC Capabilities Statements*

RTI developed a sample format for the dissemination of information on areas of expertise at each Regional Technology Transfer Center. The sample format, developed in response to a request by NASA HQ, was based on information describing the Mid-Atlantic Technology Applications Center.

### **Support to HQ and Centers**

- RTI gave an overview of the Technology Applications Team technology transfer activities to the **NASA Operations Intercenter Work Group (OIWG)** at Ames Research Center. The Team participated in discussions concerning effective mechanisms for the OIWG to pursue technology commercialization. In follow-up, Mel Montemerlo, NASA HQ Code C, and Peter Friedland, NASA Ames, have asked RTI to assist in identifying technology commercialization opportunities in the area of intelligent data analysis. RTI is marketing selected intelligent data analysis technologies under development at NASA Ames and Jet Propulsion Lab (p. 30).
- The RTI Technology Application Team met with the **Antenna and Microwave Research Branch at Langley Research Center**. Technology transfer concepts were discussed to assist this branch with documenting past activity and to plan for more effective, proactive technology transfer processes in the future. Subsequently, the RTI Team prepared an informational flyer for the AMRB windshear detection technologies and attended the 5th and Final Combined Manufacturers' and Technologists' Airborne Wind Shear Review Meeting in September 1993 at Hampton, VA.
- At the request of the **Lewis Research Center Technology Utilization Office**, the Applications Team contacted the **American Iron and Steel Institute (AISI)** and the **American Coke and Coal Chemicals Institute (ACCCI)** to determine the need for improved sealing of coke oven doors. The Team arranged a telephone conference call among Lewis, AISI, ACCCI, LTV Steel, and Shenago Steel. The conference call determined that controlling leakage from coke oven doors is an industry-wide problem with significant economic impact.
- The RTI Team provided information on **heavy metal removal from industrial wastewater** to the Lewis Research Center Technology Utilization Office. RTI also identified potential



funding from the EPA Risk Reduction Engineering Laboratory for the **Lewis Research Center's unique ion exchange material**. RTI assisted LeRC in identifying markets and potential commercial partners. RTI also contacted the Southwest Research Institute for help in making ion exchange polymers in different forms.

- RTI made a presentation on the development of dual-use technology transfer projects to the **"Primary Targeted to Secondary Targeted Technology Transfer" Process Improvement Team**.
- RTI participated as a member of the **Lewis Research Center Process Improvement Team on Secondary Targeted Technology Transfer**. The Process Improvement Team was chaired by Bruce Banks. Mr. Lehrman helped identify barriers to secondary targeted technology transfer, proposed solutions to overcome these barriers, and evaluated the likelihood that the solutions could be implemented and their effectiveness.
- RTI met with Dr. Joan Vernikos, Director NASA Life Sciences and Applications Division, to discuss RTI support to NASA Life Sciences technology transfer and dual-use development plans. Code UL will supply a list of eight candidate technology projects for our assessment.
- RTI provided a response to Dan Goldin and Courtney Stadd of NASA HQ on ways to **measure NASA's technology transfer success and to improve technology transfer**.
- At the request of the **Mid-Continent RTTC**, RTI investigated the field of telemedicine in order to provide recommendations to the RTTC in implementing their **telemedicine demonstration project** (using the digital funduscope developed at JSC). RTI provided a report summarizing certain telemedicine projects including those that will use the new ACTS satellite. In addition, we provided contacts at two companies which expressed interest in collaborating in this project.
- RTI participated in the **1993 NASA Technology Transfer Conference, South Lake Tahoe, CA, April 5-7, 1993**. The meeting provided an opportunity to improve networking with all elements of the NASA Technology Transfer Network.
- RTI performed comprehensive reviews of two technology transfer ideas submitted through Kennedy Space Center. The first proposal dealt with an **automotive air conditioning compressor** for a new, non-ozone depleting refrigerant. The second was a residential and commercial **air conditioning application of a thermal storage technology** developed for the space program. The reviews were documented in a report and submitted to the Technology Utilization Office at KSC.
- Information about new technologies was gathered at Kennedy Space Center on September 2, 3. Meetings were held with researchers in the following disciplines: advanced software, atmospheric sciences, fluids, electronics & instrumentation, non-destructive examination and

## 1.0 HIGHLIGHTS

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human factors engineering. A number of good prospects for commercialization were discussed. Commercialization efforts are underway for several of these technologies.

- RTI provided the NASA Center for Aerospace Information (CASI) with several recommendations for stories for the next (1994) issue of *Spinoff*. Most of these spinoffs resulted either directly or indirectly from RTI's involvement. Information and contacts were transmitted to CASI to enable them to do the followup.
- RTI provided a white paper for marketing of new technologies and patents for Langley Research Center.
- At the request of Kennedy Space Center, RTI met with Mr. David Thompson at Goddard Space Flight Center. Mr. Thompson is the Chief, Economic and Commercial Crime Division, Victoria, Australia. Mr. Thompson was visiting the United States to discuss applications of U.S. technology, including NASA technology, to combat computer crime. The meeting was hosted by Don Vargo (GSFC) and attended by Ray Gilbert (HQ) and Kevin Jackson (NIC).
- RTI supported NASA Lewis by obtaining items for display at the MedTech 93 conference.
- RTI is currently assisting Marshall Space Flight Center in a review of potential technology commercialization candidates. One of the team members travelled to MSFC to meet with researchers. While at MSFC the team member participated in a Technology Applications Review meeting.
- RTI conducted a study of best practices for assessment and marketing of technologies. Sources consulted in the study included MIT, University of Chicago/Argonne National Labs, and the University of California System.

## 2.0 BASIC CONTRACT STATUS

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This section summarizes the status of the deliverables for the basic Technology Applications Team contract (NASW-4367) with RTI. Status reports for the contract add-on tasks are presented in Section 6.0.

The RTI Team's results in meeting its contract requirements are summarized in Table 1. Problem statements prepared by the Team during the reporting period are presented in Section 4.0. In addition to these new projects initiated during this reporting period, the RTI Team continued to assist the NASA Field Centers in developing and monitoring projects initiated in previous contract periods. The RTI Team's activities in the coordination of these ongoing projects are described in Section 5.0.

The statement of work for the Team specifies that transfer opportunities should be developed in the following five disciplines: (1) Automation/Artificial Intelligence (Robotics), (2) Bioengineering, (3) Electronics, (4) Materials, and (5) Rehabilitation. Table 1 includes a column indicating the classification of each project by discipline.

## 2.0 BASIC CONTRACT STATUS

TABLE 1: Contract Status October 1992 - September 1993				
Problems Prepared by Team	Opportunity	RTOP	Category	Center
Joining Techniques for Advanced Composite Materials (bonding, bolting, welding, fusion...)			M	
Nondestructive Testing of Food Packages	Yes		I-A	LeRC MSFC
Real Time Temperature Measurement of Aluminum Sheet and Plate	Yes		I	GSFC
Reliable Occupant Sensing for Lighting Control	Yes		E	JPL
Sterilization Verification: Residence Time of Food Particles in Pipes	Yes		I	MSFC KSC JSC
Using Non-Contact Sensors to Determine the Linear Relationship Between the Crop, Ground, and Machine*	Yes		I-E	JPL
Using Sensors on Agricultural Equipment to Reduce Human Risks*	Yes		I-E	JSC JPL
Using Sensors to Detect Potentially Hazardous Atmospheres in Production Agriculture*	Yes		I-E	ARC JSC
Using Sensors to Determine Soil Property Data*	Yes		I-E	ARC LaRC JPL
Using Sensors to Measure and Control the Application Rates of Liquid and Granular Agricultural Materials*	Yes		I-E	JPL
Using Sensors to Continuously Measure Crop Yield*	Yes		I-E	JPL

### Center Codes:

KSC = Kennedy Space Center  
JPL = Jet Propulsion Laboratory  
JSC = Johnson Space Center

ARC = Ames Research Center  
SSC = Stennis Space Center  
LaRC = Langley Research Center

LeRC = Lewis Research Center  
MSFC = Marshall Space Flight Center

HQ = NASA Headquarters  
GSFC = Goddard Space Flight Center

### Category Codes:

R = Rehabilitation  
B = Biomedical  
I = Industry

E = Electronics  
M = Materials  
A = Automation

\*Source: Equipment Manufacturers Institute in association with the National Agricultural Library.

**TABLE 1: Contract Status October 1992 - September 1993 (Cont'd.)**

<b>Problems Referred by Field Centers Requiring Significant Team Activity</b>	<b>Opportunity</b>	<b>RTOP</b>	<b>Category</b>	<b>Center</b>
Advanced Regenerative Adsorption Cooling	Yes		I	JPL
Fiber Optic Probe for Early Cataract Detection	Yes		B	LaRC
Gamma Ray Collimator	Yes	Yes	I	SSC
Modular Sensor Conditioning System	Yes		E/B	ARC
Self-Nulling Eddy Current Probe (Simpson Probe)	Yes		E/M	LaRC
Ultrasonic Displacement Amplitude Measurement	Yes	Yes	E	LaRC
Virtual Visual Environment Display (VIVED)	Yes	Yes	B/E	JSC

**Center Codes:**

KSC = Kennedy Space Center      ARC = Ames Research Center  
 JPL = Jet Propulsion Laboratory    SSC = Stennis Space Center  
 JSC = Johnson Space Center      LaRC = Langley Research Center  
 LaRC = Lewis Research Center    HQ = NASA Headquarters  
 MSFC = Marshall Space Flight Center    GSFC = Goddard Space Flight Center

**Category Codes:**

R = Rehabilitation    E = Electronics  
 B = Biomedical      M = Materials  
 I = Industry          A = Automation



### 3.0 TECHNOLOGY COMMERCIALIZATION

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In FY93, RTI has been very successful in its proactive efforts to transfer NASA technology to U.S. industry. The following section reports on the following activities and outcomes of RTI's commercialization support to NASA:

- Commercial Products in FY93
- Industry Agreements in FY93
- Technology Opportunity Announcements
- Commercialization Workshops
- Early Stage Market Assessment Activities

#### COMMERCIAL PRODUCTS IN FY93

RTI's continuing emphasis on the transfer of NASA technology to U.S. industry has led to the commercialization of 3 RTI-assisted projects in FY93:

- **The Capaciflector marketed by Computer Application Systems, Inc. (CASI) for commercial applications requiring proximity sensing.** NASA GSFC will receive a 5% royalty on gross sales. Commercialization resulted from an RTI Technology Opportunity Announcement. RTI prepared a Spinoff! sheet and assisted in the preparation of a NASA Spinoff magazine article.
- **An advanced Multichannel Flow Cytometry System has been developed by Ratcom, Inc.** is a second generation product of a dual-use flow cytometry development project involving NASA's Johnson Space Center, the American Cancer society and Ratcom, Inc. A multichannel system has been delivered to JSC for assessment for use on Space Station, and Ratcom will market the clinical system internationally. RTI originally identified the mutual interest of JSC and ACS, conducted a national workshop to define the scope of the project, and assisted in developing cofunding for this dual-use project.
- **The BladderScan™ Monitor for monitoring and recording bladder fullness is being produced by Diagnostic Ultrasound Corporation for use in the management of urinary incontinence in patients suffering from spinal cord injury, stroke and a number of other conditions affecting bladder control.** The BladderScan™ system incorporates ultrasound technology licensed from NASA's Langley Research Center. RTI initiated this project in discussions with the Association for Retarded Citizens and the National Institute on Disability and Rehabilitation Research. RTI found the solution in technology at LaRC, developed cofunding from public and private sector sources, assisted in the development of the project plan, identified industry partners, and assisted in the preparation of the 1993 NASA Spinoff magazine article.

### 3.0 TECHNOLOGY COMMERCIALIZATION

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#### INDUSTRY AGREEMENTS IN FY93

Agreements with industry partners are an important tool for establishing cooperative projects. In FY93, RTI has been very active in developing agreements and facilitating a timely negotiation and approval process. RTI's accomplishments in the development of both Space Act and licensing agreements in FY93 are:

The **National Center for Manufacturing Sciences (NCMS)** and **NASA Langley** are in final negotiations for a reimbursable **Space Act Agreement** to fund the development of **Optically Stimulated Electron Emission for inspecting the cleanliness of printed circuit boards**. This dual-use project will develop the technology for both industry inspection of circuit boards and NASA inspection of critical weld surfaces of the solid rocket motors. RTI worked with NCMS to identify the industry requirement and with Marshall Space Flight Center and Langley Research Center to identify the NASA requirement and nondestructive testing technology. RTI assisted the Langley Technology Utilization Office in development of the project plan and Space Act Agreement.

RTI facilitated negotiations that led to the signing of a **Space Act Agreement** for the **Contextual Alarm Management System (CALMS)** between a corporate partner and Johnson Space Center. This dual-use project will develop technology both for medical monitoring of astronauts and for improved medical monitoring during surgery and in special education classrooms. RTI identified the technology need with a national panel of special education experts, identified the JSC technology and mission requirement, identified an interested industry partner, and facilitated the development of the project plan and Space Act Agreement.

**Healthdyne Technologies, Inc.** and the University of Central Florida have signed a research contract and license agreement that will allow the **Medical Oxygen Concentrator Project** to move forward with Kennedy Space Center. Under the agreement, Healthdyne will fund all of the remaining Phase II plan in exchange for exclusive rights to medical use. Healthdyne's involvement in this project resulted from an RTI Technology Opportunity Announcement and discussions with industry.

After a Technology Briefing at Kennedy Space Center(organized by RTI) **Red Pepper Software** has secured a software license from Kennedy Space Center for the **Ground Processing Scheduling System (GPSS)**. This artificial intelligence-based software was developed to handle the massive scheduling task of preparing shuttle orbiters for their next missions. Red Pepper also reports that they are close to an agreement to provide the software and services to one of the attendee companies at the KSC Technology Briefing.



**A Space Act Agreement for the Ice Detection and Thickness Measurement** project between Raton Technology Research (RTR)-- formerly Stolar/RIMTech, and Johnson Space Center was initiated in September 1993. RTI supported this commercialization effort by contacting FAA and industry to review the technology. Through this technology, NASA and RTR will be helping to meet a major FAA concern-- detecting ice on aircraft to prevent accidents.

ABB Amdata has signed a license agreement to commercialize the convolver for real-time information and signal processing (CRISP) technology from NASA Langley. Also, a similar license agreement with Westdyn is awaiting final signature. Both companies learned of this technology at an RTI-assisted commercialization workshop at NASA Langley, and both are negotiating joint development agreements with NASA Langley for further development.

#### **TECHNOLOGY OPPORTUNITY ANNOUNCEMENTS**

To assist the NASA Field Centers in locating companies to commercialize technology developed at the Center, RTI provides proactive support in the preparation of Technology Opportunity Announcements, planning Commercialization Workshops, and assessing the commercial potential of technologies.

**Technology Opportunity Announcements** are brief descriptions of a NASA technology with commercial potential. The announcement includes information on potential applications and markets for the technology as well as a technical description and information on patent status. These announcements are prepared by RTI only after a careful market assessment to determine commercial potential. Approximately 10% of the technologies assessed by RTI have sufficient commercial potential to warrant preparation of an Opportunity Announcement. RTI distributes the announcements through targeted mailings to companies in the relevant technology and market areas. In addition, RTI sends the Announcements to the NASA Regional Technology Transfer Centers and the National Technology Transfer Center.

RTI's success in locating industry partners through these techniques is shown in the table on the following page.

1. The first part of the document is a list of names and addresses of the members of the committee.

2. The second part of the document is a list of names and addresses of the members of the committee.

3. The third part of the document is a list of names and addresses of the members of the committee.

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# Technology Opportunity Announcements

*A tool for marketing new technologies*



Technology Title	Center	Date	Status
Capaciflector	GSFC	Mar-91	Commercial product with royalties paid to NASA
Convolver for Real-time Image & Signal Processing (CRISP)	LaRC	May-92	Two companies negotiating licenses; completion expected Dec. '93
Oxygen Concentrator	KSC	Jun-92	License Agreement Signed
Predictive Sensor Technology - Thermometer	SSC	Nov-92	Space Act Agreement signed 12/01/93
Modular Sensor Conditioning System	ARC	Dec-92	Discussions with 2 medical companies & potential project with chip manufacturer
Ultrasonic Displacement Amplitude Measurement	LaRC	May-93	6 companies interested, workshop held Oct-93, commercialization plans due Feb-94
Cataract Probe	LeRC	Jul-93	Following up with target companies
Virtual Reality Data Visualization (VIVED)	JSC	Jul-93	Following up with target companies
Flaw Detection Device	LaRC	Oct-93	8 companies interested, workshop held Oct-93, commercialization plans due Feb-94

### **3.0 TECHNOLOGY COMMERCIALIZATION**

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Technology Opportunity Announcements prepared in FY93 are included in Appendix B . RTI progress in commercializing these technologies in FY93 is described below.

#### **Stennis Space Center Predictive Response Algorithm**

The Applications Team has assisted SSC in the commercialization of the SSC Smart Sensing technology and the predictive response algorithm it employs. RTI developed a series of Technology Opportunity Announcements to enable useful discussion of the technology with potential commercial partners. RTI identified and contacted IVAC, a major medical monitoring company, with whom NASA is now negotiating a Space Act Agreement for a Phase 1 proof-of-concept project. The project scope was the result of an RTI assisted meeting at IVAC on June 30, 1993. Both NASA and IVAC are confident a Space Act Agreement will be signed early in FY 94 and the project will proceed.

#### **Modular Sensor Conditioning System**

NASA Ames contacted the Team with a request for assistance in commercializing the Modular Sensor Conditioning System. RTI developed a Technology Opportunity Announcement which was used at Technology 2002 where the system was demonstrated. RTI also identified and contacted 28 companies identified as having a potential commercial interest in the system. RTI scheduled visits by two of the companies to Ames for demonstration and discussions relating to the system. RTI is supporting Ames with the direct transfer of this technology in addition to project development for an Analog Data Module based on the system. Currently one of the companies is providing insight into commercial requirements to facilitate future commercialization efforts.

#### **Fiber Optic Probe for Cataract Detection**

RTI is helping Lewis Research Center to locate partners for cooperative development and commercialization of the Fiber Optic Probe for Cataract Detection. RTI has obtained an expression of interest from the National Eye Institute (NEI) for evaluation of the Fiber Optic Probe in controlled clinical trials funded by NEI. As a result of an RTI-developed Technology Opportunity Announcement, Woodlyn Corp. and Meridian Medical Lasers have expressed commercial interest. RTI is assessing the interest and potential of these two entities as possible corporate partners. Funding in the amount of \$100K is needed for clinical prototype development testing.

### **Particle Fallout Detector**

An automated, battery powered system for detecting and recording particle fallout activity has been developed by the Kennedy Space Center. The detector supplements their usual method of collecting samples on witness plates (for subsequent microscopic examination) with a technique that also tells them when the particles accumulated on the detector. The advantages this device has over more expensive detectors include compactness, battery operation and the ability to generate time history records of fallout. While more analytical comparisons are required, preliminary indications are that this device may actually be more accurate than much more expensive units for certain types of fallout.

KSC has requested RTI assistance in commercialization. Several potential markets exist and need to be assessed. Possible uses include clean room monitoring, environmental monitoring in manufacturing industries such as semiconductors and pharmaceuticals, security monitors (fallout activity increases rapidly when a person enters a quiescent space), and monitoring of any other space that requires cleanliness (such as certain medical care environments). RTI is currently conducting a market assessment and a Technology Opportunity Announcement draft is in process. The Florida Technological Research and Development Authority (TRDA) will be involved in promoting this opportunity to Florida companies.

### **Virtual Visual Environment Display (VIVED)**

The RTI Team prepared a Technology Opportunity Announcement for the Virtual Visual Environment Display (VIVED) from Johnson Space Center. The Announcement briefly describes the technology developed by JSC to take CT or MRI image data and build three dimensional graphics models for educational displays. JSC is seeking a commercial partner to acquire the technology to develop commercial software for medical anatomy education and other purposes.

The Announcement was used by JSC for a local technical conference. RTI distributed the Announcement to targeted companies and to the RTTCs for their assistance in locating a commercial partner. RTI has also arranged an invitation for JSC to give a presentation on this technology to the Association for the Development of Computer-based Instructional Systems (ADCIS) annual meeting. We continue to hold commercialization discussions with various interested parties.

### 3.0 TECHNOLOGY COMMERCIALIZATION

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#### COMMERCIALIZATION WORKSHOPS

In support of NASA Field Center technology commercialization, RTI assists in the planning and implementation of Commercialization Workshops, an interactive forum for industry to learn about specific technology transfer opportunities at NASA. The goals of a commercialization workshop are to (1) provide companies with information on the technology, its advantages, disadvantages, potential applications and markets, and its patent status, and (2) inform companies on how to apply for a license or propose a collaborative project with NASA. RTI support for these workshops includes identifying candidate companies, developing and disseminating materials to these companies, organizing the workshop format, taking part in discussions, and assisting NASA in follow-up activities with companies. Brief summaries of RTI support to seven Commercialization Workshops for four Field Centers are presented below.

##### Kennedy Space Center Workshop on Conducting Polymers

The Technology Application Team assisted with the Kennedy Space Center technology commercialization workshop on developing protective coatings for metal with conducting polymers. Nine different candidate organizations were present, and several submitted commercialization plans. Los Alamos National Laboratory (LANL) and KSC staffs evaluated the plans and one company was selected.

This effort resulted in the first Cooperative Research and Development Agreement (CRADA) involving both the National Aeronautics and Space Administration and the Department of Energy (DOE) since the Memorandum of Understanding was executed between them on July 9, 1992. NASA will not be a signatory on the CRADA; however, they had significant input during the selection process and they will have an involvement during the execution of the development project. DOE LANL negotiated the CRADA with the selected company and submitted a proposal for funding to DOE headquarters. The funding has yet not been provided for the DOE involvement. NASA KSC is prepared to participate as soon as DOE follows through.

##### Ground Processing Scheduling System

The Team assisted the Kennedy Space Center Technology Utilization Office with an on-site Technology Briefing on the scheduling software: Ground Processing Scheduling System (GPSS). This meeting was designed to bring all know interested parties together for a comprehensive look at the software and its application. The software, developed jointly by NASA, Ames, KSC, and Lockheed Missiles and Space company, is an artificial intelligence-based system that has proven itself in scheduling the processing of orbiters between missions. The GPSS software was subsequently spun-off to one of the developers who is handling the commercialization of the technology. This company, Red Pepper Software, negotiated a license for the GPSS software,

and they are responsible for follow-up with the interested companies. Interest in the software is based on its potential for applications in manufacturing, maintenance, distribution and medical care.

#### **Advanced Regenerative Adsorption Cooling**

The Technology Applications Team, with the Air Conditioning and Research Institute (ARI), organized a commercialization workshop for JPL's Advanced Regenerative Adsorption Cooling technology. Industry participation was coordinated through the Air Conditioning and Refrigeration Institute. The meeting was held in conjunction with the American Society of Heating, Refrigeration & Air-conditioning Engineers (ASHRAE) in Chicago, IL on Sunday, January 24, 1993. Forty-two individuals attended representing equipment manufacturers, gas utilities, industry consortia and associations, DoE, SDIO, and NASA. The industry participants provided technical guidelines that must be met by the NASA system before being of interest to the commercial sector. As a result of the workshop a relationship was formed between JPL, Aerojet and Lennox.

#### **Goddard Space Flight Center Photonics Commercialization Workshop**

The Goddard Space Flight Center is a lead NASA center for photonics and electro-optics technology development. A number of photonics components and systems are being developed for earth remote sensing, satellite communications, and astronomy applications. The Goddard Technology Utilization Office enlisted the assistance of the Applications Team to promote these technologies through a commercialization workshop. The Applications Team initially met with the Goddard scientists and engineers and explained the purpose of the workshop, the anticipated audience, and recommended a presentation format based on the Applications Team's experience with similar workshops. At the same time, the Applications Team publicized the workshop through numerous trade journals such as Photonics Spectra, Laser Focus World, Optics & Photonics News, and Research & Development Magazine. The Applications Team prepared a mailing list of over 500 companies and the Goddard TU Office sent these companies an invitation to attend the March, 1993 workshop. Companies attending heard presentations by eight Goddard photonics researchers and one Goddard SBIR-funded company. Significant interest was expressed in the Ultra-High Sensitivity, Absolute, Linear and Rotary Encoders, a NASA patented technology. The Goddard TU Office and the researcher continue discussions with companies interested in licensing this technology. The Applications Team continues to investigate licensing and cooperative development for two additional photonics technologies: the High Power, Diffraction-Limited Semiconductor MOPA Laser and the Polarimetric IR Spectrometer.

### **3.0 TECHNOLOGY COMMERCIALIZATION**

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#### **Powder Curtain Prepreg Technology Commercialization**

The Langley Research Center has invented and patented a new process for manufacturing composite prepregs. The process involves spreading the fiber out and impregnating the fibers with a dry polymer powder. The process has significant advantages over current processes in its through-put and non-use of solvents. The Applications Team worked with the Langley Technology Utilization Office to identify potential licensees for the technology. The Team contacted the Society for the Advancement of Materials and Process Engineering which provided a list of the major prepreg materials producers. Using the Thomas Register and Corp Tech directories, the Team identified and screened more than 20 companies that either made prepreg manufacturing equipment or prepregs. The Team worked with Langley to develop a brochure describing the powder curtain prepreg technology and mailed the brochure to the selected companies. Electrostatic Technologies of Massachusetts and Polymer Composites, Inc. of Minnesota submitted to Langley information describing their use for the technology and business intentions. These companies were invited by Langley to a commercialization workshop in July.

#### **Self-Nulling Eddy-Current Probe (Simpson Probe)**

The Team assisted in the technology commercialization efforts at Langley Research Center for the self-nulling eddy-current probe (Simpson Probe). Specifically, RTI completed a market assessment, identified potential commercialization partners, prepared a brochure outlining the technology, and invited target companies to a Technical Briefing at Langley. The briefing is to be held in conjunction with the Technology Opportunity Showcase in October.

#### **Ultrasound Amplitude Displacement Measurement**

The Applications Team is assisting the Langley Research Center in locating a company to license the patented electrostatic acoustic transducer and its use for absolute measurement of acoustic displacement. The Team contacted over 40 companies and has received inquiries from 6. These six have been invited to the commercialization workshop planned in conjunction with the Langley Technology Opportunity Showcase in October.

#### **MARKET ASSESSMENT ACTIVITIES**

The following technology commercialization efforts have not yet proceeded to either Technology Opportunity Announcements or workshops. The Team is conducting Market Assessments in order to guide a subsequent commercialization strategy.



### **Gamma Ray Collimator**

The Stennis Space Center has invented and patented a new robotic-assisted nondestructive testing instrument for inspection of thick concrete and steel pressure vessels and structures. The gamma ray collimator more closely focuses radiation on the area to be inspected thereby reducing both exposure time and the safe operating regime. The Applications Team worked with the Stennis Technology Utilization Office to perform a market analysis for the gamma ray collimator. Stennis loaned to RTI a report purchased from Frost & Sullivan regarding the nondestructive testing marketplace. Using this report, information from Thomas Register, and the Corp Tech database, RTI compiled a list of companies that manufacture or use similar test equipment. RTI sent these companies a letter describing the gamma ray collimator and explaining that NASA was interested in licensing the technology. Instrument Marketing Services Company of Hoboken, NJ responded to the mailing and contacted the Marshall Space Flight Center legal counsel regarding licensing the gamma ray collimator. At this time, Instrument Marketing Services has submitted to Marshall a license application and has visited the Stennis Space Center to meet with the gamma ray collimator inventor and the Stennis TU Office.

### **Prisoner Locator Technology**

At the request of Kevin Jackson, National Institute of Corrections, the Applications Team investigated the commercial-off-the-shelf market for equipment that could be used in prisons to individually identify and locate prisoners. Mr. Jackson requested this information in support of a JPL proposal to develop an individual prisoner identification system. The Team found that equipment can be broadly classified into three groups.

1. Duress alarms
2. Access control systems
3. Personal identification and location systems

The Team found that duress alarms and access control systems are currently available technology. The Team also found that there is no commercial-off-the-shelf technology that can uniquely identify and locate a prisoner to within 10-20 feet within a prison system. Materially is still developing the Prison Headcount and Identification Locator System (PHILS) and at least one other company is considering adapting a hospital patient system for prisons.

### 3.0 TECHNOLOGY COMMERCIALIZATION

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#### **NASA Operations/Artificial Intelligence Technologies**

##### *High Resolution Surface Modelling From Multiple Images*

NASA scientists have been on the forefront of image enhancement technologies. Cameras on earth observing satellites and planetary probes record images as a montage of pixels, each containing elementary information about the area represented. Processes which effectively resolve this information into finer pixel patterns provide analysts with sharper images and more useful information. A new technique for super-resolution has been demonstrated for still images. By making use of multiple images of the same area, and by applying more sophisticated rules for the relationships among information-bearing pixels, scientists at Ames Research Center may have set the stage for dramatic changes in several graphics-based industries.

The new technique has been demonstrated on 2-D images. It is proposed that 3-D images can similarly be generated and that, with further refinements, full motion video can be sharpened with derived techniques. Potential applications include: security - generate high resolution images from typically blurry video images; publishing - sharpen pictures used in newspapers that are based on video images; commercial television - potential for picture quality that exceeds that of high definition television (HDTV).

A market assessment is required to determine the potential users and providers of this technology. This technology appears to be an excellent candidate for dual use development, covering NASA's needs for better image processing techniques and industry needs in a variety of applications. The intellectual property protection issue needs immediate attention. A paper was published in January 1993. This opportunity will be pursued by RTI in conjunction with two University of North Carolina Business School MBA students who will perform market segmentation analysis followed by selection of target companies.

##### *Scientists' Intelligent Graphical Modeling Assistant (SIGMA)*

SIGMA is a general purpose modeling tool designed for use as an efficient mechanism for prototyping scientific models. Researchers at the Ames Research Center have demonstrated SIGMA by creating modeling codes which support several different scientific analyses.

The status of this opportunity is described by:

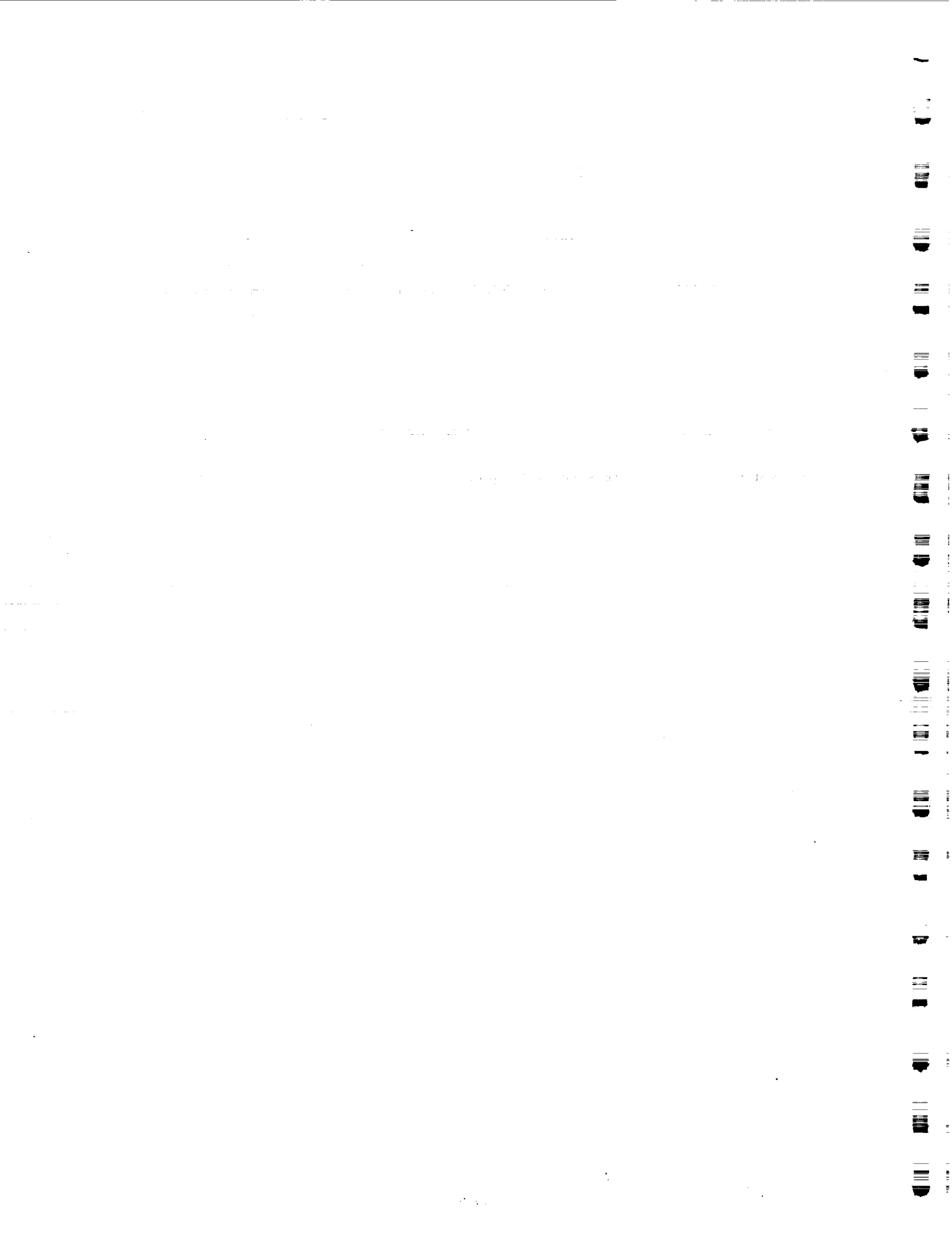
- Initial market assessment was completed and turned out positive.
- Technology Opportunity Announcement was drafted, reviewed and is in revision.
- Selection of target companies is beginning.

*Temporal Directed Acyclic Graph (TDAG)*

TDAG is a flexible sequence-learning algorithm with many potential uses. Its basic technique can be used as an efficiency enhancement tool for a number of data handling computer applications. Researchers at the Ames Research Center have employed the Temporal Directed Acyclic Graph (TDAG) algorithm to develop dynamic optimization routines to reduce program execution times, to compress text files, and to provide intelligent caching which enables more efficient access to secondary storage operations.

The status of this opportunity is described by:

- Initial market assessment was completed and turned out positive.
- Technology Opportunity Announcement was drafted and sent to Ames for review.
- Selection of target companies is beginning.



## 4.0 NEW PROBLEM STATEMENTS

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**PROBLEM TITLE:** Joining Techniques for Advanced Composite Materials (bonding, bolting, welding, fusion, ...).

**SOURCE OF PROBLEM:** University of Delaware/Center for Composite Materials (CCM) and the National Center for Manufacturing Sciences (NCMS)

**DATE:** March 3, 1993

### Technology Required

Methods are sought to join composite material parts into an assembly with better quality, faster processes and reduced cost. Improvements are required over current methods in the areas of joint strength, reliability, speed of joining, use of energy, and the ability to join dissimilar materials. Improvements are also desired in automated operations, process control using nonintrusive sensors and real-time non-destructive inspection. The best technologies will also exhibit the most flexibility in accommodating a wide range of material types, geometries and conditions.

### Description of the Problem

There are three methods for joining composite materials: adhesive bonding, mechanical joining and fusion. Combinations of the three are also used. Each of the three share some common challenges.

Mating parts have to fit together well and be carefully aligned to prevent voids in the bond and to assure a uniform thickness of the adhesive in the joint. The thickness of the adhesive in the finished joint determines the strength of the joint. Thicker joints tend to loose shear strength compared to thinner joints.

There are no standards or design criteria for design of adhesive joints. Until these are developed, progress in mass production techniques is likely to be very slow.

Other areas requiring improvement for all joining methods include inspectability of finished joints, improved creep and peel characteristics, and better resistance to environmental degradation.

Problems specific to the different joining methods are described below.

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##### Adhesive Bonding

Joints made with adhesives tend to take longer to accomplish. Lengthy curing times and elaborate surface preparations increase production costs. High rates of production are not practical in many cases. For bonds made in autoclaves with heated presses, the extended curing process consumes a significant amount of electrical energy. Improved adhesive joining techniques are sought which will be faster, cheaper and better than current techniques.

##### Mechanical Joining

Improved designs for bolting are also desired. Bolt pullout and bearing performance are not adequate in many instances, especially when joining thinner parts. Drilling methods for fastener holes are not yet optimized for a number of materials. Galvanic corrosion in joints involving mechanical fasteners and materials with carbon fibers has been a problem for designers that has not been satisfactorily solved.

##### Fusion

Fusion of composite materials is often referred to as welding. The processes are very similar between metal joining and thermoplastic composite material joining. Induction, ultrasonic and resistance welding techniques are the most often used. Fusion joining techniques are usually lower in cost due to reduced cycle times and less involved surface pretreatment.

Problems remain unsolved with a number of fusion methods, and improvements are necessary for advances in the quality and cost of many more. The following list includes some of the techniques and improvements that are sought:

- Improved thermoplastic adhesives for joining dissimilar materials
- Automated systems for resistance welding
- Methods for analyzing and predicting joint strength
- Sensor technology for observing and evaluating the process in real time
- Improved joint durability

##### Importance of the Problem/Solution

The benefits of major improvements in joining technology are potentially enormous. In order to take advantage of the enhanced performance of newer materials, joining techniques must keep pace. The future of the aerospace and commercial airplane industries may well be told by the success, or lack thereof, that the U.S. has in developing and applying advanced composite material systems. The automobile industry is already seeing the effects of more pervasive use

of these materials. Breakthroughs in joining techniques are essential for securing competitive edges in these fields. "Joining and assembly methods that provide static and dynamic structural integrity, long term (15 - 20 year) durability and can be integrated into robust manufacturing processes, are key to use of advanced materials for automotive and space structures [8]."

### **State of the Art**

Compared to the technologies for joining conventional materials, the corresponding methods for use with composite materials are in their infancy. Most of the techniques discussed above have been developed on low volume, expensive parts and processes. Advances are absolutely imperative in the high volume, lower cost parts sector if the advantages of these materials are to be realized. Not only are mass production techniques almost totally lacking, there has been little work done to characterize the processes that are being considered. Joint efficiencies, strength characteristics, dynamic life characteristics, cost and manufacturability are paramount considerations. In addition, the degree to which specific processes can be incorporated into flexible manufacturing environments will also be key to the future value of the methodologies.

### **Status**

As a result of the problem statement on joining technologies for composite materials, 12 responses were received from as many laboratories. This problem statement had been distributed to the NASA Field Centers and over 200 laboratories in the Federal Laboratory Consortium for Technology Transfer. The responding laboratories are listed below.

### **Responding Laboratories**

Princeton Plasma Physics Laboratory

George Washington University

United States Army  
US Tank and Automotive Command

Air Vehicle Structures Division  
Department of the Army  
Aviation and Applied Technology Directorate

National Aeronautics and Space Administration  
Lewis Research Center

Advanced Systems Concepts Office (SMCAR-ASC)  
Department of the Army  
U.S. Army Armament Research, Development and Engineering Center

Composites Structures/Materials Structures Directorate

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Research, Development & Engineering Center  
U.S. Army Missile Command

Naval Surface Warfare Center  
Dahlgren Division  
White Oak Detachment

Westinghouse  
Savannah River Company

Albany Research Center  
United States Department of Interior  
Bureau of Mines

Engineering Materials Team  
Engineering Materials and Coatings Division  
Department of the Army

Thiokol Corporation (Through NASA Marshall Space Flight Center)  
Research and Development

The Center for Composite Materials (CCM) was interested in pursuing additional information on two of the submitted technologies. RTI organized telephone conference calls with the CCM and the two affected laboratories: Advanced Systems Concepts Office (SMCAR-ASC), Department of the Army, U.S. Army Armament Research, Development and Engineering Center, and the Naval Surface Warfare Center, Dahlgren Division, White Oak Detachment. Both calls went well and the parties plan to pursue very promising mutual interests. since no linkages were made with NASA Centers for this problem statement, RTI has ceased activity for this issue.



**PROBLEM TITLE:**           **Nondestructive Testing of Food Packages**

**SOURCE OF PROBLEM:** **National Food Processors Association**

**RTI PERSONNEL:**       **Molly O'Donovan Dix**

### **Background**

The food processing industry, represented by the National Food Processors Association with over 500 member companies, seeks new methods and technology for nondestructively testing food packages for leaks, which may be as small as 25 to 100 microns, and contamination. The ideal situation would be to test every package during routine processing without requiring changes in the packages.

Food processors are required by law to assess the integrity of the packages they distribute. Package defects are rare--they occur in approximately 1 in 10,000 packages under optimal conditions and approximately 1 in 5,000 on average. However, the consequences of container failure are enormous. Examples exist of entire food industries, covering several countries, becoming paralyzed or even collapsing due to a defect in one package. The food packaging industry spends millions of dollars a year on testing package integrity to prevent package defects that can unleash a loss of consumer confidence and paralyze the market.

The principal function of food packaging is to prevent the contamination of food products by bacteria, thus protecting its wholesomeness and purity. Health concerns resulting from bacterial contamination will vary according to the type of microorganisms supported by the particular food type.

Packages are made of glass, metal, paper, and plastic--each with different closure designs. Packages must serve many functions and, because every feature adds cost, most food packages are optimized and stripped to the bare essentials. They provide barriers to bacteria, aroma, moisture and oxygen; provide stacking strength and abuse resistance; fit into the hand; suit consumers lifestyles; and are convenient, resealable, microwaveable, and, above all, reliable. Packages are designed to market food--not to be tested easily. Methods must be devised to test packages that do not require changing the packaging itself.

Testing is used by the food industry to identify, isolate, and prevent microleaks in food packages. Almost all testing involves removing samples from the production line and uses methods that destroy the packaging in the process. This line sampling and destructive testing is inefficient, expensive, and wasteful. The food processing industry seeks new technology to

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replace this testing method with a non-destructive method. On-line nondestructive tests offer several advantages:

- Better precision than human inspectors
- More consistency in accept/reject decisions
- Better day-to-day reliability
- Ability to evaluate every package.

There are 19 test methods, each modified to work best with a container shape, closure or material, that are used to test food packages for microleaks. Although each test method has its advantages, there are also disadvantages to each. Limitations include:

- Most tests must be conducted in a laboratory using specialized tools.
- Some tests, like incubation, are slow.
- Most require sample packages from the production line or the warehouse.
- Detecting a very small, but significant defect is limited by statistical sampling methods.
- Skilled personnel are required to detect package defects on a fast-moving conveyor belt.
- Most current tests destroy the package.
- Special fixtures are required to attach sensors to the packages for nondestructive testing.

The biggest limitation of destructive tests is that they destroy the package. Nondestructive testing offers speed, reduced product loss, increased line efficiency, and the possibility of 100 percent inspection. Existing on-line nondestructive testing devices can cost up to \$500,000. New or untried nondestructive test methods could significantly improve the rate of package defect detection over current testing methods.

This is the first of several problem areas identified by the National Food Processors Association.

#### **NASA Technologies**

Many methods from other industries have been largely untried on food packages. Possible solutions include but are not limited to:

- Video image processing
- Ultrasound methods that do not require direct coupling
- Laser scanners
- Force measurement systems (to measure forces necessary for bacteria to pass through micron-sized holes)
- Sensors that can be incorporated into labels indicating bacteria within a sterilized container
- Remote sensing technology
- Radar methods to detect openings.

### **Participants**

- Dr. Lester Crawford, Executive Vice President, Scientific Affairs, National Food Processors Association
- Dr. Jeffrey Barach, Vice President Eastern Research Laboratory, National Food Processors Association
- Mr. Austin Gavin, National Food Processors Association
- Dr. Barbara Blackistone, National Food Processors Association

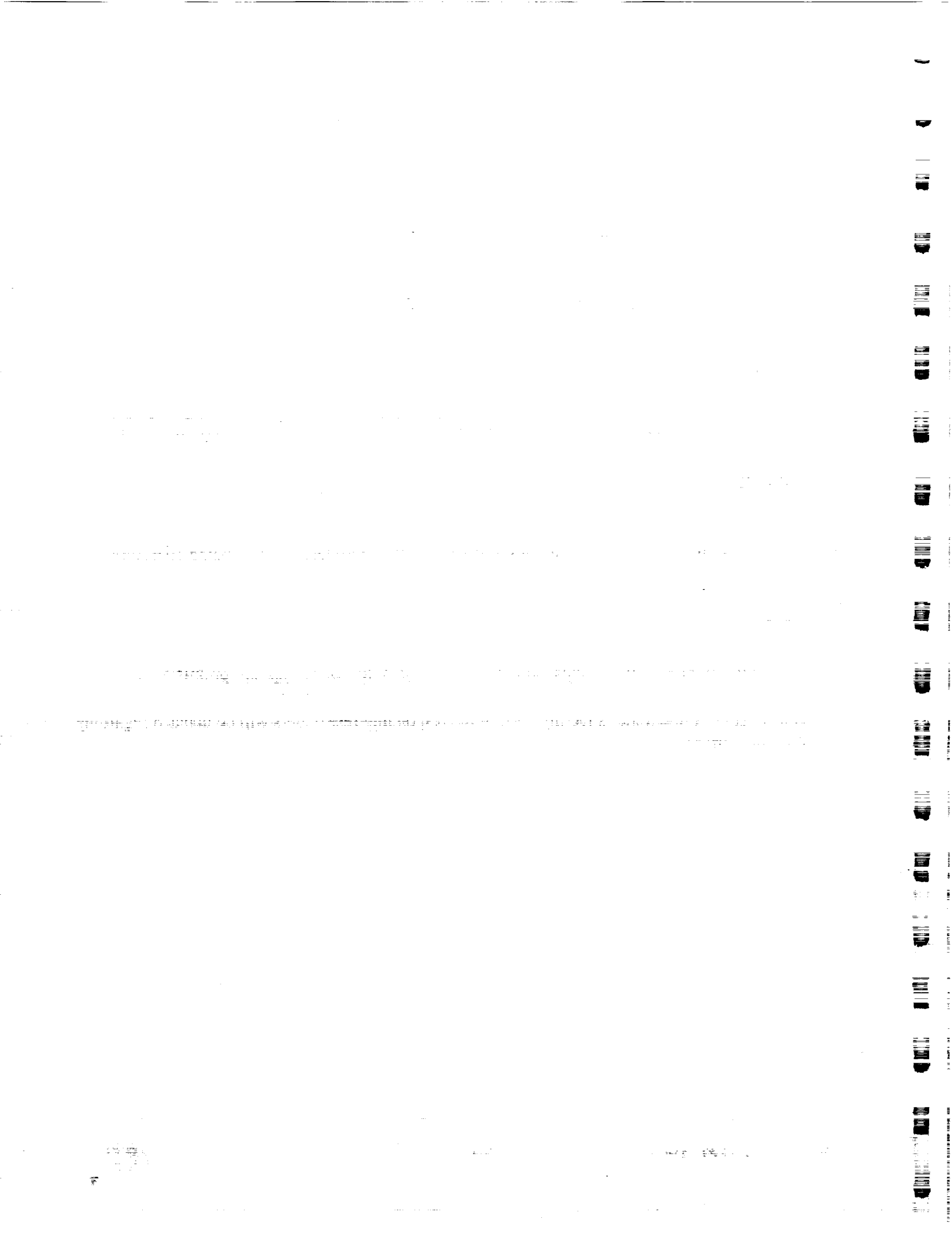
### **Status**

The problem statement was distributed to the Field Centers in January. It was subsequently sent to other federal laboratories via the Federal Laboratory Consortium, in accordance with the NASA/FLC agreement. Twelve responses were received including NASA, NIH, USAF, USDA, and DOE.

Following review by the National Food Processors Association's industrial subcommittee, three technologies were selected for further discussions. The three technologies being considered are from DoE and NIH.

### **Action**

RTI will arrange conversations with the researchers to follow up on promising matches. Following that, RTI will pass along the opportunity to the appropriate technology transfer contact at each researcher's facility. All of the responding researchers will be updated regarding the final outcome.



**PROBLEM TITLE:** Real Time Temperature Measurement  
of Aluminum Sheet and Plate

**SOURCE OF PROBLEM:** Aluminum Association, Inc.

**RTI TEAM PERSONNEL:** Stephen A. Lehrman

### **Background**

Hot rolling of aluminum sheet and plate requires accurate temperature monitoring for feedforward and feedback control of the rolling mill. Bars 40-80 inches wide enter the mill at less than 100 ft/min and exit as hot rolled coils at approximately 1000 ft/min. Surface temperature is typically measured using infrared pyrometers or thermocouples.

Infrared pyrometers are manufactured by many companies. Infrared pyrometers look at the radiated light off the surface of the aluminum product and calculate the surface temperature. Most infrared pyrometers operate at a wavelength below 4 micron. The amount of radiated light is affected by the emissivity of the aluminum and by reflection from bright lights in the work area. The emissivity of aluminum product is very low (  $\approx 0.1$  ) and is a function of the aluminum temperature, composition of the alloy, process conditions, surface finish, state of oxidation of the surface, and wavelength at which the measurement is performed. The influence of each factor on the emissivity of the aluminum surface can vary greatly. Bright lights also cause reflection off the aluminum surface which introduces errors into the infrared pyrometer measurement. Under relatively constant process and environmental conditions, commercial infrared pyrometers can measure the surface temperature to  $\pm 10$  °C over the required temperature range.

Thermocouples are contact temperature measurement instruments. Because they must be in direct contact with the material to be measured, thermocouples are difficult to use on moving aluminum sheet and plate. Aluminum rolling mills have not been able to achieve the desired temperature accuracy using thermocouples.

The temperature measurement instrumentation must be able to measure the surface or bulk temperature of aluminum sheet and plate moving at 1000 ft/min without contacting the material. The required accuracy is  $\pm 2$  °C at 50 °C to  $\pm 5$  °C at 600 °C. The instrumentation must be able to operate continuously, 24 hours a day, in an environment that contains steam in the air, dust, vibration, electrical noise, electromagnetic fields, and bright ambient lighting. The

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environmental temperature ranges from 0 °C to 100 °C. The instrumentation should be easily calibrated, reliable, and exhibit no drift. The sensor head should be located a reasonable distance away from the aluminum surface, although this requirement is flexible. The instrumentation should be able to measure the temperature at multiple points across the width (40-80 inches) of the aluminum product. Either a sensor array or scanner is acceptable. The instrumentation should be able to transmit temperature information to the rolling mill computers for process control. Commercial instrumentation, once developed, should not cost more than \$20,000 per measurement station.

#### **NASA Technology**

A total of five responses were received from NASA Goddard/Wallops Island, Los Alamos National Laboratory, Oak Ridge National Laboratory, Lockheed/NASA White Sands Test Facility, and the University of Arkansas-Little Rock. All responses suggested some form of optical pyrometry.

Dr. Kate Forrest of NASA Goddard/Wallops Flight Facility recommended triple wavelength infrared pyrometry implemented with commercially available, state-of-the-art uncooled detector array technology. All three wavelength would be in the far infrared from 8 to 12 micron. This wavelength band is particularly appropriate for measuring the temperature of aluminum because the emissivity of aluminum varies about half as much at these wavelengths as it does at lower 2 to 4 micron wavelengths. Even more importantly, between 8 to 12 microns the emissivity of aluminum varies linearly to a high degree for temperatures between 0° and 750°C, and the linearity is strongest at lower temperatures where accurate measurement is most difficult.

#### **Participants**

- Mr. Seymour Epstein, Aluminum Association
- Mr. Otto Meijer, Alcan Rolled Products Division

#### **Status**

Mr. Meijer stated that the Aluminum Association sub-committee on temperature measurement of aluminum sheet had reviewed all the proposals submitted. Mr. Meijer stated that, at this time, the Aluminum Association was going to proceed only with funding the present work at the National Institute of Standards and Technology on using eddy current methods for determining the aluminum temperature.

##### **Action**

The Applications Team plans to continue to discuss this project with Mr. Meijer and Mr. Epstein on a regular basis. If the eddy current method fails to provide accurate temperature measurements, or if the Aluminum Association desires to try an advanced pyrometry approach, the Team will be prepared to initiate a cooperative project.





**PROBLEM TITLE:** Reliable Occupant Sensing for Lighting Control  
**SOURCE OF PROBLEM:** Manufacturer of lighting products  
**RTI TEAM PERSONNEL:** Molly O'Donovan Dix

### **Background**

Today's environmental awareness and the resulting political climate limit construction of new power generating facilities. Emphasis is now placed on renewable energy sources and energy conservation. To continue supplying power at the ever-increasing level of demand, utilities are looking to their customer's systems and equipment for efficiency improvement opportunities.

A common technology encouraged by utilities in the residential, commercial and industrial sectors is lighting control based on occupant sensing. Numerous utilities currently offer some kind of incentive to customers for installation of occupant based lighting control. In addition to lighting, occupant sensing control is also used for Heating, Ventilation, Air Conditioning (HVAC) control.

Existing technologies (including passive infrared and ultrasonic) used for occupant sensing could be improved in many ways. A more effective or reliable sensing element at a comparable cost may better motivate customers to install devices without incentives from their utility. The entire population gains from conservation efforts and thus a redesign of the existing sensing technologies will have a broad benefit.

### **System Requirements**

- The system should reliably detect a six-inch hand movement at twenty feet.
- The system should have a 180° viewing angle.
- The system should provide a targeted sensitivity to "human" presence to avoid false triggering.
- The system should cost less to manufacture than existing systems. Existing commercial systems typically cost \$10 to \$20 to manufacture. For residential systems the detector must be manufactured for less than \$3.

### **NASA Technology**

None of the NASA Field Centers that responded to the problem statement had existing technologies that could improve on currently available commercial technology. However, applicable technology was identified at the Jet Propulsion Laboratory.

Regent Lighting has expressed interest in JPL's tunneling infrared technology (contact Dr. Thomas Kenny) and long wavelength infrared detector technology (contact Richard P. Vasquez). Both technologies are available for license from NASA.

### **Status**

A technology at Lawrence Livermore National Laboratory was also identified as a potential transfer opportunity. Regent will follow up on this lead independent of TAT services.

RTI facilitated preliminary conversations between Regent and the Patent Counsel at JPL and identified Dr. J. Rooney as a contact for the JPL Affiliates Program. RTI also outlined other contacts that could provide access to Federal technologies including the Southern Technology Applications Center (Regent's RTTC) and the FLC Locator in Sequim, WA.

**PROBLEM TITLE:** Residence Time of Food Particles  
in Stainless Steel Pipes

**SOURCE OF PROBLEM:** National Food Processors Association

**RTI TEAM PERSONNEL:** Molly O'Donovan Dix

### **Background**

The food-processing industry, represented by the National Food Processors Association (NFPA) with over 500 members companies, seeks a noninvasive method to measure the time an individual particle takes to move through a length of 316 stainless steel pipe. A food product in two-phase flow (liquid with solids) passes through the pipe with pressures of approximately 60 psig and temperatures of 270-285°F.

Traditional food processing uses a retort process in which the product and its container are sterilized together. However, in some applications an aseptic process is used. In this process, the food is sterilized at high temperatures for short periods of time (20-120 sec.), the package is sterilized separately, and the two are brought together in a sterile environment where the container is filled with the food and sealed. The aseptic process provides better control and higher quality taste to the end product.

Although products such as juice in juice boxes, milk, and ice cream can currently be processed using the aseptic method, foods with particles, such as stews and spaghetti, cannot be because there is no FDA-approved method for determining adequate sterilization. To enable particulate two-phase food processing to utilize this superior process, food processors require a method that provides a velocity measurement of the fastest moving particle passing through a hold tube. If the fastest particle remains in the tube for a minimum time, the food can be identified as adequately sterilized.

Specifically, the food industry seeks a noninvasive method (i.e., one that does not impede the product flow) to measure the time it takes for a food particle to move from one end of the tube to another. The mean velocity of all the particles cannot be used since there is a velocity distribution. Ten to twenty of NFPA's member companies have an interest in this method since they are looking for a method to determine the shortest residence time over a statistically representative number of particles. This information will be used to determine if the food has been properly sterilized. Safety of the food product is of primary importance to this industry. The system could be used in the United States and internationally to provide better tasting and safer processed foods for consumers.

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- noninvasive such that it does not impede food product flow
- capable of measuring individual particle velocities
- functional with food in two phase flow (particles in opaque solution)
- function with food in 316 stainless steel pipe

	TYPICAL	MAXIMUM
Pressure (psig)	60	100 +
Temperature (°F)	270-285	300 +
Flow Velocity (m/s)	0.1	1
Pipe Diameter (in.)	1.5	2
Pipe Wall Thickness (in.)	0.065"	—
Pipe Length (in.)	> 100"	—
Particle Density (g/ml)	1 to 1.2	—
pH	4.6	—
Particle Size	0.25"	—
Mix Ratio	5-80% particles/liquid	

#### NASA Technology

The problem statement generated 29 responses from four agencies. The responses from NASA are as follows: MSFC, 2; SSC, 1; LaRC, 3; JSC, 1; KSC, 3.

#### Status

The preliminary review by the NFPA has identified 3 NASA technologies and 1 Naval proposal as the most promising. The NASA technologies are from MSFC, KSC and JSC. However, all of the technologies are still being reviewed.

#### Action

RTI will move forward with the NFPA to bring the appropriate technologies to their members' attention. It appears several NASA technologies may be of interest. We will assist those researchers with the NFPA interface. All other researchers that proposed solutions will be updated on the project status.

**PROBLEM TITLE:** Using Non-Contact Sensors to Determine the Linear Relationship Between the Crop, Ground, and Machine

**SOURCE OF PROBLEM:** Equipment Manufacturers Institute in association with the National Food Processors Association

**RTI TEAM PERSONNEL:** Molly O'Donovan Dix

## **I. Technology Requirements**

A multiple use distance/position sensor is needed to enable the development of overall system(s) that will detect (1) the presence and location of a crop, or (2) the location of the ground. The detected presence and location of a crop enables positioning the machine by steering so the maximum cutting width of the crop is maintained. The detected location of the ground enables positioning the harvester head so it maintains a constant height regardless of change in ground contour.

## **II. Background: Problem and Impact of Solution**

Automating the control of the many varied functions of agricultural products is an on-going effort. The operators of agricultural equipment are faced with many controls and monitors that require constant attention. From a behavioral standpoint, agricultural equipment operators are often driven by a sense of urgency to complete a given task as quickly as possible. They experience long hours, overwork, fatigue, and continual changes in the workplace environment related to weather, time of day, type of operation, and crop/soil conditions. These combine to heighten the probability of human error resulting in productivity loss, machine damage, and in extreme cases can result in injury.

Modern machines have been equipped with a large variety of conveniences such as air conditioned cabs, electro hydraulic controls, systems performance monitors, and microprocessor controllers to improve the environment, simplify controls, and reduce fatigue for operators. Further improvements depend largely on the development of new and improved sensors to interface with the electronic controllers. The sensors are needed for (1) controlling the height of the harvesting heads, and (2) steering or guiding the crop harvesting equipment. A distance/position sensor that meets the required specifications will most likely be used in a number of other applications and on other products.

The cost to produce farm machinery continues to increase while the customer base continues to shrink. Providing value through improvements in productivity as well as operator convenience is a continuous process. Containing cost while improving features is of major concern.

### III. State-Of-The-Art

**Header Height Control.** The current header height control system utilizes a rotating tube which is suspended beneath a header. The tube is fitted with several fingers that rub on the ground. The length of the tube and the quantity of feelers is dependent on the length of header (up to thirty feet) being used. The rotating tube is fitted with an arm that rotates with the tube and is connected to a potentiometer by a push/pull cable. The potentiometer sends a signal to the height controller, and the header is subsequently adjusted to the cutting height of the crop.

**Automatic Guidance Systems.** Guidance systems are currently supplied as an after-market attachment for row crop applications only. In the future, manufacturers of agricultural equipment will likely make this feature available either factory installed or as a dealer installed option. There are a variety of systems available, but each requires a mechanical device to contact the crop or ground to sense position. The mechanical device is connected, using linkages or cables, to a potentiometer that transmits an electrical signal to a controller. The controller transmits a signal to the steering control valve or steering motor that is adjusted as commanded. These are typically closed-loop systems.

**Improvements Needed.** Both of these systems use mechanical devices attached to electronic sensors (potentiometers) that provide information to an electronic controller. These systems require frequent adjustments and/or replacements due to wear on the contact surfaces and in the pin joints. The mechanical feeler that is in contact with the crop or ground needs to be replaced.

New and developing sensor technology, combined with increasing use of state-of-the-art electronic systems offer the potential for reducing the (1) frequency of adjustments on equipment, (2) replacements of mechanical feelers, and (3) operator's effort.

#### IV. Technology Constraints and Specifications

##### A. Design and Functional Requirements

1. **Height Controls.** The sensor must be able to detect the ground either in standing or down-crop conditions. (Note: "Down crop" refers to a condition where a crop that is normally standing erect has fallen down and is laying on the ground due to an outside influence, such as wind, rain, or hail.) Farm fields may contain either all standing or all down crops, and it is not unusual to find areas of down crop within a field of good standing crop.

The sensor(s) must be able to penetrate the foliage when present and identify the ground below as the proper reference; then use this factor as a reference to determine the height of the header which cuts the crop. The sensor(s) must be able to maintain the reference when traveling from standing crop to down-crop, to a combination of both conditions, with no operator adjustments. The size and location of the sensor(s) must not interfere with the normal operation of the equipment.

**Guidance Controls.** The sensor(s) must be able to detect the cut crop edge either in standing or down-crop conditions. It must also detect and maintain the reference in crops that are planted or drilled in rows, or when randomly sown. It must be able to maintain the reference when traveling from standing to down conditions, and at any angle to the planting direction, with no operator adjustments. The size and location of the sensor(s) must not interfere with the normal operation of the equipment.

2. **Range.** The operating range is 0 to 76 centimeters for height position, and 0 to 7.6 centimeters for guidance.
3. **Accuracy.** The accuracy for height control is 2 percent of range (15 millimeters) maximum, and for guidance the accuracy is to maintain position from 0 centimeters missed crop to 5 centimeters maximum overlap into the cut area.
4. **Repeatability.** The height control must return to the selected position (repeatability) within 1 percent of the maximum lift range (7.6 millimeters).

5. **Response Times.** The sensor must update and correct its signal each 0.01 second minimum. (At 11 kilometers per hour, 0.01 second is approximately equal to 3.0 centimeters of forward travel.)
6. **Voltage Requirement.** The equipment this sensor will be applied to operates between +9.8 and 16 vdc. Ground is provided by a 12.0 vdc battery return, isolated ground.
7. **Machine Operating Speed.** The equipment this sensor will be applied to will travel between 0 and 15 kilometers per hour while operating in the automatic mode.
8. **Reliability.** The sensor must have a minimum  $b_{10}$  life of 7,000 hours at the 70 percent confidence level.
9. **Environmental Requirements.** The sensor must meet ANSI/SAE Standards EP455 (see attached) including electromagnetic compatibility (EMC) or electromagnetic interference (EMI) testing. These requirements include, but are not limited to, exposure to rain, mud, dust, wind, vibration, and impacts up to 4 g's. Operating temperatures will range from -30°C to +70°C, and storage temperatures from -40°C to +85°C.
10. **Safety.** Must be "fail safe", i.e., fail in a way that does not suggest normal operation. The system must respond to a manual steering input that ends automatic operation until the operator elects to reset the automatic feature. If the automatic feature fails, the system must allow the operator to continue operating the equipment manually, and must not discourage safe action.
11. **Other.** Technology for these systems must provide minimum interference with job objectives, and it must have operator acceptance. Technology should be:
  - Simple to operate;
  - Easy to understand;
  - Highly reliable;
  - An enhancement to machine function and job production, not a constraint; and
  - Pleasant to use, not a nuisance.



**B. Cost Constraints**

Unit cost should not exceed \$50.00/sensor. Estimated initial sales volumes are 10,000 - 100,000 units annually, depending on the number of applications for a system that meets this specification.

The quantity required for the specific applications referenced in this specification are:

**Height Controls.** Two sensors standard; three optional. It is assumed that, due to the extreme width of headers, one sensor would be required for each end as standard equipment. Machines that operate in undulating ground may require an optional third sensor near the center of the header.

**Guidance Controls.** One sensor standard, two optional. It is believed that most customers use the left end of the header as the cut line, so one sensor installed on the left side would be standard. The sensor also could be installed on the right end if the customer chooses. An optional second sensor could be made available for guidance from either end.

**V. References**

ASAE Standards 1993. American Society of Agricultural Engineers, 1993.

ANSI/ASAE EP455, Environmental Considerations in Development of Mobile Agricultural Electrical/Electronic Components.

Automatic Equipment Company, manufacturer of guidance systems, located in Pender, Nebraska.

Orthman Manufacturing Inc., manufacturer of guidance systems, located in Lexington, Nebraska.

ASAE Technical Paper No. MNSK91-105, Computer Vision for Agricultural Vehicle Guidance.

Patent Number 5,155,984, Implement Height Control.

Patent Number 5,155,983, Distance Measurement and Control Using Coded Sonic Signals.

ASAE Technical Paper 913539, Sensor Needs for Combine Harvesters

Sentek Weighing and Control Systems, manufacturer of height control systems, located in Saskatoon, SK, Canada.

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**PROBLEM TITLE:** Using Sensors on Agricultural Equipment  
to Reduce Human Risks

**SOURCE OF PROBLEM:** Equipment Manufacturers Institute in association  
with the National Food Processors Association

**RTI TEAM PERSONNEL:** Molly O'Donovan Dix

### **I. Technology Requirement**

A sensor-based system is needed that will detect, warn and/or compensate for the presence of operators and other people when they are in close proximity to operating agricultural machinery where a potentially hazardous condition exists. The use of any such system should be limited to situations which, if not avoided, will result in serious injury or death.

### **II. Background: Problem and Impact of Solution**

Entanglement in or contact with moving elements of agricultural machinery continues to be a mode of farm accidents that frequently results in serious injury or death. Currently used safety strategies such as passive barriers, safety signs and messages, and operator education/training have been shown to be only partially effective in alleviating this situation.

Surveys have revealed that it is not unusual for farmers to remove the protective shields and guards over moving machinery parts for servicing or for adapting equipment for different uses, without replacing them. Moreover, there is a variety of equipment, such as soil working tools, and crop cutting/gathering mechanisms where the presence of a guard would render the machine nonfunctional.

From the behavioral standpoint, agricultural equipment operators often strive to complete work tasks as quickly as possible. Overwork, fatigue, risk taking, and continual changes in the workplace environment related to weather, time of day, type of operation and crop/soil conditions combine to heighten the probability of behavior that results in serious injury or death from entanglement in or contact with moving machinery.

At present, the magnitude of this problem or the potential for remediation cannot be determined, because there is no valid statistical database.

### III. State-of-the-Art

**Passive Barriers, Safety Signs and Messages, Education/Training.** These are some methods currently used to enhance safety. However, they have been shown to be only partially effective in alleviating the situation.

**Interlock Systems.** Interlock systems are used in a few agricultural equipment applications such as for: preventing the engine from starting unless the transmission is in a neutral position (ref: ASAE Standard S318; SAE Standard J208); stopping the moving parts of forage wagons; operator restraint systems for skid steer loaders (ref: SAE Standard J1388); and shutting off some moving parts of cotton pickers when the operator leaves the seat. See attached ASAE paper 88-5516, "Human Presence Activated Safety Systems for Mobile Off-Road Equipment", for a general discussion of "state-of-the-art."

**Radar, Infrared and Ultrasonic Sensor Technologies.** Research conducted by the industry in the 1980's indicated that commercially available radar, infrared and ultrasonic sensor technologies did not perform satisfactorily for agricultural and industrial equipment applications.

Nonetheless, new and developing sensor technology, coupled with increasing use of state-of-the-art electronic systems on farm machinery, keeps active the concept of systems to sense the presence (or absence) of people in relation to a hazard and to initiate an appropriate system response.

### IV. Technology Constraints and Specifications

#### A. Sensor Design and Functional Requirement:

1. Must sense the presence of any person, including a child.
2. Must sense the presence or absence of the machine operator or other person in relation to a hazard on functioning agricultural machinery, so that there can be a significant reduction in the likelihood of entanglement or other machine contact:
  - a. when the operator is not at the designated operator's station; and/or
  - b. when any person is in the proximity of the hazard.

3. The dimension of the monitored envelope (surrounding) must be at least equal to the dimension of the hazardous zone. The size and shape of the hazardous zone will differ greatly by application. It may be as large as a 20 ft. (6.10 m) spherical radius or it may be a narrowly-defined volume enveloping a part of a mechanism.
4. Must differentiate consistently and effectively between people and other objects such as crops; other machinery; and some forms of wildlife, e.g., rabbits, quail and pheasants, when the functioning machine is moving or stationary. Must not give a false positive when such objects enter the sensor's field of view. (See Subsection B of the section – system requirements.)
5. Should be capable of use with implements towed by or otherwise coupled to various makes or models of tractors, as well as with self-propelled equipment. (Farm machinery utilizes a 12 volt negative ground electrical system.)
6. The size and locations of the sensor(s) must not interfere with normal operation of the equipment, i.e., the system must provide "transparency" (unobtrusiveness) when recommended procedures for machine operations or servicing are followed.
7. Response time (sensor): not more than a few milliseconds.
8. After initial calibration, must operate without need for adjustment or realignment over the specified range of environmental conditions, and for the life of the sensor.
9. Environmental requirements. Must meet ANSI/ASAE Standard EP455 (see attached), including but not limited to:
  - Operating temperature (Level 3):  $T(\text{max}) = +70^{\circ}\text{C}$ ;  
 $T(\text{min}) = -30^{\circ}\text{C}$ .
  - Storage temperature (Level 2):  $T(\text{max}) = +85^{\circ}\text{C}$ ;  
 $T(\text{min}) = -40^{\circ}\text{C}$ .
10. Reliability requirements. Must have a minimum  $b_{10}$  life of 7000 hrs. at the 70 percent confidence level.

### B. System Design and Functional Requirements:

1. Must provide minimum interference with job objectives; must have operator acceptance:
  - Simple to operate;
  - Easy to understand;
  - High reliability;
  - Should enhance, not constrain, machine function and job productivity; and
  - Must not present a nuisance.
2. Must not discourage safe action.
3. Must be difficult to defeat, bypass, or disable.
4. Must be "fail-safe," i.e., fail in a manner which does not give an indication of normal operation. Must have a self diagnostic capability so as to indicate or correct any disabling malfunction.
5. System response must be swift enough to neutralize the hazard potential prior to human contact under foreseeable circumstances, and not so slow as to require an unnecessarily large and potentially objectionable monitored zone. The probable system operating response is in milliseconds.
6. Allowable probability of a false positive response when machine is functioning is unknown; when machine is inert (shut down) it is zero. Any false positives may be unacceptable to the user.
7. Allowable probability of a false negative response is also unknown; however, a false negative is believed to be nearly intolerable.
8. Activation must not require an intentional act of the user; however, the system must: (a) allow for legitimate, intentional but temporary deactivation for functional purposes (such as working with mechanical power take-off driven implements) without impairing productivity; and (b) be reactivated automatically upon completion of such legitimate work tasks.
9. Upon machine start-up, must be actuated by an automatic or semi-automatic function which does not depend on the operator "remembering" to take some action. However, it must also

require an intentional act to reset it if the system is deliberately deactivated for legitimate functional reasons (see Item 8 above).

10. Must be integral with the basic machine, not an add-on.
11. Should provide some further function--such as an audible and/or visual alarm--to enhance the safety of the operator if he or she is sensed to be in the "wrong" place at the "wrong" time.
12. Environmental requirements. Must meet ANSI/SAE EP455 (see attached).
13. Reliability requirements. To be determined.

#### C. Cost Constraints

The cost of the whole system, not of the sensor(s) alone, is the dominant factor. The cost of the system may be acceptable to the end purchaser if the system can be integrated with readily valued (and value-added) features/capabilities. Customer acceptance of incremental cost increases is usually related to the price of the whole product package which, for agricultural equipment, ranges from under \$5000 to as much as \$200,000.

Estimated initial sales volumes in the agricultural equipment industry are 10,000 - 100,000 units annually (U.S. only), depending on the number of applications for which a system is shown to meet the criteria specified herein. A successful system could potentially be adapted for use in the construction, mining, forestry, materials handling, transportation and manufacturing industries.

#### V. References

SAE Standards 1993. American Society of Agricultural Engineers, 1993.

Proposed revision of SAE Standard S318.10 DEC92, Safety for Agricultural Equipment.

ANSI/SAE Standard EP455, Environmental Considerations in Development of Mobile Agricultural Electrical/Electronic Components.

SAE Technical Paper No. 88-5516 "Human Presence Activated Safety Systems for Mobile Off-Road Equipment," Karl Anderson and Gary Smith, American Society of Agricultural Engineers, 1988.

SAE Standard J208 AUG86, Safety for Agricultural Tractors.

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**PROBLEM TITLE:** Using Sensors to Detect Potentially Hazardous Atmospheres in Production Agriculture

**SOURCE OF PROBLEM:** Equipment Manufacturers Institute in association with the National Food Processors Association

**RTI TEAM PERSONNEL:** Molly O'Donovan Dix

## I. Technology Requirement

Lower cost, faster responding sensors that detect more chemicals are needed for separate systems to (a) continuously monitor or (b) rapidly detect the presence of atmospheres that are potentially hazardous to people or farm animals, and to warn against and/or compensate for them. There are generally three kinds of hazardous atmospheres in production agriculture:

- Oxygen deficient
- Toxic
- Flammable or explosive

Systems that *continuously monitor* atmospheres could be stationary, portable, or installed in a farm vehicle such as a tractor. Systems that *rapidly detect* potentially hazardous atmospheres would be carried or worn by a person.

## II. Background: Problem and Impact of Solution

Agricultural workers are exposed to certain biogenic gases produced in "confined spaces" including, but not limited to liquid manure retention pits and silos. Workers also are exposed to a variety of chemicals used as pesticides, herbicides and fertilizers in the form of vapors, aerosols or particulate matter. Agricultural chemicals can reach hazardous concentrations in storage and mixing areas, open fields and orchards (during or after application), and in the enclosed cabs of tractors and other machinery.

The more serious atmospheric hazards found in production agriculture are manure gases, silo gases, and agricultural chemicals:

**Manure Gases.** Liquid manure storage systems have come into prominent use in recent years. Many dairy, beef and hog operations (and to a limited extent poultry operations) now use liquid manure systems as a fast and economical method of handling animal wastes. These systems, particularly if

they are incorporated into enclosed livestock housing facilities, may pose a serious hazard because of the gases they produce (see attached, ASAE EP470).

Decomposing animal manure gives off a variety of gases including hydrogen sulfide, carbon dioxide, ammonia, and methane. The accumulation of these gases within the confined space of the manure pit can produce an oxygen-deficient, toxic, and/or explosive environment. Of these gases, hydrogen sulfide and ammonia are the most toxic.

Because hydrogen sulfide ( $H_2S$ ) is heavier than air, the gas has a tendency to accumulate on the surface of the manure. Over a period of time, the undisturbed accumulation of the gas, along with a rising level of liquid manure in the storage system, may force the gas above floor level (if the storage system is located under a structure, such as a barn).

The hazard potential is especially acute when workers enter a confined space used for the storage or transport of liquid manure for the purpose of cleaning or servicing the equipment (e.g., a transfer pump). Hydrogen sulfide has been responsible for many animal deaths as well as occasional human deaths. The human deaths sometimes tragically include multiple family members because one person is unsuccessful in rescuing another.

**Silo gases.** Silage fermentation may produce several kinds of gas, including carbon dioxide, oxides of nitrogen ( $NO$ ,  $NO_2$ , and  $N_2O_5$ ) and sulfur dioxide. Farmers must occasionally enter tower silos at or near the top, above the stored silage, to manage the process of removing portions of the silage for the feeding of animals, or to service equipment. Farmers can gain access to the silo by two methods: (1) climbing a ladder which is surrounded by a chute mounted to the exterior wall and entering through one of several small "doors" located at various height intervals, or (2) climbing another ladder mounted on the exterior wall and accessing only the top of the silo.

A silage blower might be available and could be used to ventilate the upper chamber before entry and for the duration of the work. Because nitrogen dioxide is heavier than air, it remains beneath the air mass, hovering over the silage. The gas can form a layer on top of the silage below the upper edge of the top door, or it settles down through the chute. Nitrogen dioxide also may seep through the drain at the base of the silo. It often concentrates in the silo room and moves into the barn, posing a threat to both animals and workers.

**Agriculture Chemicals.** People who work with or near herbicides, pesticides, fungicides or fertilizers may be at risk for both acute and chronic health hazards. Acute pesticide poisoning accounts for an estimated 20,000 emergency room visits each year, and approximately 10 percent of these cases are admitted to the hospital.

Currently, approximately 600 active pesticide ingredients are used. Typical chemical families include triazines, dinitroanilines, phenoxyis, thiocarbamates, acetylanalides, organophosphates, and pyrethrums. (See *Farm Chemical Handbook*, Meister Publishing Co., 1992.) Agricultural chemicals may be present in an atmosphere as a vapor, aerosol, or particulate.

**Sensor-based systems offer solutions.** Sensor-based systems that continuously monitor atmospheres could be used to:

- Warn against a hazardous condition;
- Indicate the absence of a hazardous condition;
- Activate an intervention to control or eliminate a hazardous condition; and/or
- Prevent human access when hazardous conditions are present, and allow access when the hazard has been controlled.

Systems-based systems that rapidly detect presence of potentially hazardous atmospheres, worn or carried by a person, could alert the person to the hazard in time to take preventive action.

Simultaneous use of both types of systems, where practicable, would provide a higher level of safety than would use of either type alone.

### III. State-of-the-Art

A number of manufacturers offer a variety of devices to indicate the presence of gases, or the deficiency of oxygen. (See Appendix A for a partial listing of device manufacturers/suppliers.) These devices, many of which are battery-operated and portable--including pocket size--are typically used in the sewage maintenance, construction, mining, petrochemical, shipping, and power generation industries.

The types of sensors used are electrochemical cell, ion-sensitive electrode, catalytic, flame ionization detector (for hydrocarbons), and photometric cell.

Sampling is done by diffusion, electric pump or an external hand aspirator bulb. Chemicals for which sensors are commercially available include:  $H_2S$ ,  $HCl$ ,  $CO$ ,  $COCl_2$ ,  $SO_2$ ,  $NH_3$ ,  $NO$ ,  $NO_2$ ,  $PH_3$ ,  $AsH_3$ ,  $Cl_2$ ,  $F_2$ , hydrocarbons, other combustible gases, and  $O_2$ -deficiency.

However, these commercially available systems have seen only limited acceptance in production agriculture because of the:

- Cost;
- Level of skill/training required to operate;
- Size (too large to be conveniently carried by or worn on a person);
- Unavailability of sensors for many of the potentially hazardous chemicals found or used in agriculture; and
- Unacceptably long system response times.

#### IV. Technology Constraints and Specifications

The requirements for the farm chemical sensor are not well defined at this time. Some of the tentative specifications under consideration include:

**Sensitivity.** The sensor should respond to the presence of the hazardous chemical at a level below that deemed to present a long-term hazard. The sensor should be insensitive to the presence of non-hazardous materials commonly present in a particular environment such as dust, and in the case of a tractor cab, diesel engine exhaust fumes.

**Response Time.** For systems that monitor continuously, the sensor should respond within 30 seconds of reaching the level that exceeds the allowable long term exposure level. For systems to rapidly detect hazardous atmospheres, the system should respond quickly enough to enable the user/wearer to take evasive action before experiencing acute toxicity or being overcome.

**Reliability.** The sensor must have a minimum  $b_{10}$  life of 7,000 hours at the 70 percent confidence level. Probability of false positive indications must be minimal. Probability of false negatives must be zero. A warning must indicate sensor failure.

**Environmental.** The sensor must meet ANSI/ASAE Standard EP455 (see attached) including electromagnetic compatibility (EMC) and electromagnetic interference (EMI) testing. Operating temperatures will range from  $0^{\circ}C$  to  $+70^{\circ}C$ , and storage temperatures will range from  $-40^{\circ}C$  to  $+85^{\circ}C$ . Relative humidity reaches 100 percent.

**Cost Constraints:** Unit cost should not exceed \$100 (sensor only) for a single, wide range sensor. If the system requires a specific sensor for a particular chemical, unit cost should not exceed \$25.00. Estimated initial volumes for continuous monitoring type sensors are 5,000 - 20,000 units annually (U.S., production agriculture only). Annual volumes for rapid-detection sensors could run in the hundreds of thousands depending on cost.

## **V. References**

ASAE Standard EP470, Manure Storage Safety

ANSI/ASAE Standard EP455, Environmental Considerations in Development of Mobile Agricultural Electrical/Electronic Components



**PROBLEM TITLE:** Using Sensors to Determine Soil Property Data

**SOURCE OF PROBLEM:** Equipment Manufacturers Institute in association with the National Food Processors Association

**RTI TEAM PERSONNEL:** Molly O'Donovan Dix

### **I. Technology Requirement**

Sensors that can be mounted on an implement, pulled through a field are needed to output real time soil property data in order to control the application of fertilizers and other materials "on the go," or to generate a soil map. Depending on the technology utilized, the sensor might "look" at the soil surface or actually penetrate the soil surface by 1-2 inches.

### **II. Background: Problem and Impact of Solution**

As the cost and the ecological impact of farm fertilizer and chemicals continue to rise, the concept of "precision" or "prescription" farming is becoming increasingly attractive.

Precision farming recognizes that there are differences in soil type and chemical concentrations within a given crop field. These variabilities are mapped, and application rates of chemicals and seed are varied across the field in accordance with a strategy designed to maximize the farmer's return on investment.

### **III. State of the Art**

Currently, the soil data are generated by typically laying out a 300 ft. by 300 ft. grid over a field and physically taking soil samples. The samples are analyzed in a lab; the chemical/fertilizer requirements for each portion of the field are determined; and a field map is created. This "prescription" is then loaded into a computer which, coupled with a navigation aid such as Global Positioning Satellite (GPS), controls the application rates to meet prescription requirements.

To close the loop, yield data from the harvest, again on each portion of the field, also are stored in the field map and used to confirm or correct the strategy to be used in the following season.

### IV. Technology Constraints and Specifications

Sensors should be capable of determining fertility (nitrates, phosphorous, potassium); pH; moisture; and percent organic matter. Typical travel speeds across the field are in the 3 to 7 mph range.

#### A. Design and Functional Requirements

1. Sense the following items:
  - a. Nitrates ( $\text{NO}_3$ ) 5-100 ppm
  - b. Phosphorous ( $\text{P}_2\text{O}_5$ ) 2-50 ppm
  - c. Potassium ( $\text{K}_2$ ) 25-200 ppm
  - d. pH (4.5-8)
  - e. Moisture
  - f. Organic matter (0 to 6 percent)
2. Sensor processing time: less than one second is desired; less than 10 seconds is required.
3. Environmental requirements: In general, the sensor would need to be exposed to the soil representative of the field at any given location. Therefore, it would need to scour, and remain clean and free from accumulation of debris or other soils carried over from another field location.

Sensor(s) also must meet ANSI/ASAE Standard EP455 (see attached), including but not limited to:

- a. Operating temperature: 0 to 70°C
    - b. Storage temperature: -40°C to +85°C
  4. After initial calibration, sensors must operate without need for adjustment.
- B. Cost Constraints: For this to be cost effective, costs in the range of \$50 to \$100 per sensor are desired.



**V. References**

Illinois Agronomy Handbook 93-94. University of Illinois at Urbana-Champaign, College of Agriculture

ANSI/SAE Standard EP455, Environmental Considerations in Development of Mobile Agricultural Electrical/Electronic Components



**PROBLEM TITLE:** Using Sensors to Measure and Control the Application Rates of Liquid and Granular Agricultural Materials

**SOURCE OF PROBLEM:** Equipment Manufacturers Institute in association with the National Food Processors Association

**RTI TEAM PERSONNEL:** Molly O'Donovan Dix

### **I. Technology Requirement**

Inexpensive sensors are needed to measure the flow of liquids and granular materials in a variety of agricultural material application tasks. The sensors would be used to control and/or monitor the (1) application rates of both liquid and granular herbicides, insecticides, and fertilizers; and the (2) planting of small seeds such as wheat and rye.

### **II. Background: Problem and Impact of Solution**

There are two classes of materials to be sensed: liquids--fertilizer, herbicide, and insecticide; and granular materials--fertilizer, herbicide, insecticide, and small seeds. All the liquids can be applied by the same metering devices and all of the granular materials are applied with similar metering devices. It is common to apply pesticides and fertilizer simultaneously from different meters on the same machine when planting row crops.

Accurate metering and measurement of the application rates of liquid and granular materials has a significant economic impact on the success of an agricultural enterprise. This is due to the high cost of these materials and the effect of improper application on crop yield. Excessive application of many of these materials also has a negative effect on the environment. This has led to legislated requirements to record applications rates, and may lead to further requirements to more accurately control these application rates.

### **III. State-of-the-Art**

Many application systems for liquids and granular materials use open loop meters that apply at fixed or constant rates under constant conditions.

Liquid materials. Liquid applicators may rely on constant displacement pumps that are driven at fixed speeds, or on constant pressure pumps that deliver material through a fixed orifice or multiple nozzles. The application rates of

these systems deviate from the set rate when operating parameters change. Application rates are sensitive to a number of parameters such as vehicle speed, pump drive speed, system pressure, and nozzle or orifice wear, etc. Existing technology to measure high rates of liquid flow are not applicable to the low flow rates (2-200 ounces/minute) required to monitor injection spray systems, and existing sensors are too expensive to be economically feasible for monitoring individual nozzle flows (.05-8 gallons/minute) of other spray systems.

**Granular materials.** Granular flow meters experience similar unsensed and uncorrected variation in application rates caused by changing conditions. No practical sensor technology for measuring granular flow rates in mobile equipment is available at the present time.

Development of low cost sensors for these applications would lead to control systems for each nozzle of liquid applicators and for each row unit of granular material dispensers.

#### IV. Technology Constraints and Specifications

- A. **Performance.** *Liquid flow sensors* must measure with an accuracy of better than 5 percent (2 percent desired) of full flow range. The flow range is 2-200 ounces/minute for injection spray systems; .05-10 gallons/minute for individual spray nozzles.

*Granular flow sensors* must measure with an accuracy of better than 5 percent (2 percent desired) of full flow range. Granular sensor flow rate requirements vary with the application. For a pesticide meter on a planter row unit, rates range from .05-5.0 pounds/minute. Individual meters on grain drills apply at rates in the range of 0.5-5.0 pounds/minute.

- B. **Environment.** The sensor must meet ANSI/ASAE Standard EP455 (see attached) including electromagnetic compatibility (EMC) and electromagnetic interference (EMI) standards. These requirements include, but are not limited to exposure to rain, mud, dust, wind, vibration, and impacts up to 4 g's.

Operating temperatures will range from 0 to 70°C, and storage temperatures from -40 to +85°C.

Liquid sensors must withstand the corrosive effects of the liquid monitored.

- C. Reliability. The sensor must have a minimum  $b_{10}$  life of 1000 hours at the 70 percent confidence level.
- D. Cost Constraints. Unit cost should not exceed \$15.00 each. Estimated sales volume is of the order of 100,000 units annually.

## V. References

ANSI/ASAE Standard EP455, Environmental Considerations in Development of Mobile Agricultural Electrical/Electronic Components.



**PROBLEM TITLE:** Using Sensors to Continuously Measure Crop Yield

**SOURCE OF PROBLEM:** Equipment Manufacturers Institute in association with the National Food Processors Association

**RTI TEAM PERSONNEL:** Molly O'Donovan Dix

### **I. Technology Requirement**

A cost-effective means of measuring moisture, temperature, and weight (volume) of crops is needed to determine yields in the field during the harvesting process. In today's agriculture, technologies exist for taking such measurements under stationary conditions, but they have not been implemented successfully "on-the-go."

### **II. Background: Problem and Impact of Solution**

Crop harvest and the yield data from it enable the farmer to determine whether or not the production process has achieved the desired goals for the season. Knowing yield data for a specific location in a field will allow farmers to modify their strategies for future chemical applications, seed population, and field preparation.

Farmers that have survived today's competitiveness in the world marketplace have become better business people. They want to know more about their ongoing production process and are no longer willing to settle for information after the harvest or on an average basis. Farmers want to know with "precision" the important parameters associated with their operation.

Recently, the concept of "precision" or "prescription" farming has emerged as a means of better understanding the elements associated with the farming process: field preparation, chemical composition of the soil, and the yield achieved at a given location. Navigational aids, such as Global Positioning Satellites (GPS), identify the specific location of the vehicle, which is recording data. The data are placed on field maps that are maintained on computer storage media for future updates and comparisons.

### **III. State-Of-The-Art**

In stationary applications, the current technology for determining *moisture* level is measuring the dielectric properties of the grain and calibrating this value to

actual moisture as measured by a "hot air oven" method. The grain is placed in a test cell where temperatures and weight are measured. The sides of the test cell make up the plates of a capacitor. The capacitor value is then calibrated to a known moisture value.

Another stationary method utilized today employs Near Infrared (NIR) optical technology to determine the moisture content of a prepared sample. By measuring the spectral level of the different frequencies of light reflected off of the prepared sample, the moisture content of the sample can be determined through calibration methods to known samples. These methods are costly and not very conducive to mobile vehicle applications.

The three methods used for measuring *temperature* include: Resistor Temperature Detectors (RTDs), Thermo-Couples, and Thermistors. These are all suitable approaches used today in mobile applications.

The methods for measuring *weight* include strain gauge load cells and hydraulic load cells, both of which are suitable and used today in mobile applications. The volume of grain versus time can also be of interest for this application. A method used today is placing a strain gauge sensing device in the clean grain auger flow path. The force on the sensor is calibrated to the flow volume, thereby giving an indication of the volume of product flowing into the grain truck.

At present, all three methods of measurement--moisture, temperature, and weight--are required to give an accurate measure of yield. However, they all have some deficiency, mostly ease of use, cost, and accuracy of output.

#### IV. Technology Constraints and Specifications

##### A. Design and Functional Requirements

These sensors will be applied to machines that harvest a wide variety of grains and seeds, such as corn, soybeans, wheat, and sunflowers; and forage crops such as hay and straw. *It is desirable that the same sensors be used for all applications.*



**1. Feature Performance Requirements:**

Yield (bu/acre)	1 percent accuracy
Average yield (bu/acre)	1 percent accuracy
Total yield (bu/acre)	3 percent accuracy
Acres harvested	2 percent accuracy
Percent moisture	0.5 percent accuracy
Average moisture	0.5 percent accuracy

**2. Response Time and Update Rates:** A response time of 100 milliseconds or less is required to correlate location and yield data.**3. Range of Measurements:**

Moisture levels from 0 to 50 percent  
Weight measurements up to 2,000 lbs.  
Temperature from -20°C to +85°C

**4. Voltage Requirements:** The equipment these sensors will be applied to operates between +9.8 and +16 VDC.

In many cases, these sensors will be used in conjunction with controllers or monitors which can supply either +8VDC or +5VDC regulated sensor outputs.

- 5. Environmental Requirements:** The sensor(s) must meet ANSI/ASAE Standard EP455 (see attached) including electromagnetic compatibility (EMC) or electromagnetic interference (EMI) testing. These requirements include, but are not limited to, exposure to rain, mud, dust, wind, vibration, and shock impacts up to 4 g's. Operating temperatures will range from -30°C to +70°C, and storage temperature from -40°C to +85°C.
- 6. Calibration:** Sensor(s) should be self-calibrating, or should not require calibration after the initial adjustment when installed at the factory.
- 7. Reliability:** The sensor(s) must have a minimum  $b_{10}$  life of 7,000 hours at a 70 percent confidence level.

**B. Cost Constraints**

The yield measuring system should not cost more than \$200. This cost includes only the sensor(s) and not the display or monitoring units.

Annual quantities expected for this product in this application would be 5,000 to 15,000 units.

**V. References**

1. ANSI/ASAE Standard EP455, Environmental Considerations in Development of Mobile Agricultural Electrical/Electronic Components.

**PROBLEM TITLE:**            **Gamma Ray Collimator**

**SOURCE OF PROBLEM:**   **Stennis Space Center**

**RTI PERSONNEL:**         **Stephen A. Lehrman**

### **Background**

The Stennis Space Center performs nondestructive examination of thick walled pressure vessels. The conventional method for nondestructive examination of these pressure vessels is to have a radiographic source inside the pressure vessel and expose the radiographs in a panoramic fashion. Some of these pressure vessels at Stennis do not have a manway, thereby, preventing this method of inspection.

Existing technology does permit through two-wall radiographic inspection. However, the exposure time is very long (e.g. weeks) and the restricted area may exceed 1000 feet. The Stennis Gamma Ray Collimator uses salt shields to intensify the gamma radiation. The result is an exposure time measured in ten's of hours and safe stand-off distance of less than 100 feet for most applications at Stennis.

Stennis Space Center has requested assistance from the RTI Applications Team in locating commercial partners for this technology.

### **NASA Technology**

NASA has applied for a patent on the gamma ray collimator. The collimator consists of a housing having two sections. The first section encloses a radiation emitting component such as cobalt 60. The second section encloses a depleted uranium member which is provided with a conical cut out for focusing the radiation. Salt screens are used to significantly reduce radiation dispersion. A wheeled, telescopic, robotic arm can be used to precisely position the gamma ray collimator source.

### **Participants**

NASA would like to license the patent to a U.S. company. No participants have applied for the license. Amersham, Source Production & Equipment Company, and Industrial Nuclear provide gamma ray sources and are potential licensees. Also, MQS Inspection and Hartford Steam Boiler are potential field testing participants in a nonreimbursable space act agreement.

##### **Status**

The Applications Team worked with the Stennis Technology Utilization Office to perform a market analysis for the gamma ray collimator. Stennis loaned to RTI a report purchased from Frost & Sullivan regarding the nondestructive testing marketplace. Using this report, information from Thomas Register, and the Corp Tech database, RTI compiled a list of companies that manufacture or use similar test equipment. RTI sent these companies a letter describing the gamma ray collimator and explaining that NASA was interested in licensing the technology. Instrument Marketing Services Company of Hoboken, NJ responded to the mailing and contacted the Marshall Space Flight Center legal counsel regarding licensing the gamma ray collimator. At this time, Instrument Marketing Services has submitted to Marshall a license application and has visited the Stennis Space Center to meet with the gamma ray collimator inventor and the Stennis TU Office.

##### **Action**

Dr. Michael Gavini of Instrument Marketing Services company has submitted a license application to NASA. The Marshall Patent Counsel is evaluating the application. There is no further action for the Applications Team pending the completion of the Patent Counsel review.

**PROBLEM TITLE:** Modular Programmable Sensor Conditioning System

**SOURCE OF PROBLEM:** Sensors 2000! Program, Ames Research Center

**RTI PERSONNEL:** Molly O'Donovan Dix

### **Background**

NASA Ames developed a modular, programmable sensor conditioning system for physiological monitoring on the Space Shuttle. This system's modular construction makes it well suited to a variety of sensor applications. The NASA system, which is completely developed, has commercial potential for physiological measurements, process control, and other sensor signal conditioning applications.

### **NASA Technology**

The system as it exists consists of a 12-slop distributed-function backplane, seven signal conditioning cards, a three-card digital control and memory system, and two power supply cards for conditioning and isolating the output of the external power supply. The signal conditioning cards may be configured to process different sensors. The modular design also allows new signal conditioning cards to be inserted for different applications. Each card filters the incoming signal into the appropriate bandwidth, scales the signal, and sends the data to the digital controls and memory boards.

### **Participants**

John Hines, NASA Ames Research Center  
Christopher Miles, Sverdrup Technology, Inc.  
Julie Schonfeld, NASA Ames Research Center

### **Status**

Ames contacted the Team with a request for assistance in commercializing the Modular Sensor Conditioning System. RTI developed a Technology Opportunity Announcement which was used at Technology 2002 where the system was demonstrated. RTI also identified and contacted 28 companies identified as having a potential commercial interest in the system.

Motorola, Inc. expressed interest in developing an Analog Data Module (ADM) based on the NASA system. The module will be used initially by NASA for physiological measurements, but will be available for commercialization by Motorola. Daniel Winfield met with John Hines at Ames in May to discuss this opportunity. In parallel with the Motorola developments, the team scheduled and attended meetings at NASA Ames with two physiological monitoring companies

#### **4.0 NEW PROBLEM STATEMENTS**

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on June 28 and 29, 1993. In September Ames signed an agreement with Motorola to move forward with Phase 1: Specification Development, of the ADM.

Resulting from the June meetings, RTI arranged (through several conference calls) for a technical representative of one of the medical monitoring companies to spend a dy at Ames to identify specifications that the Motorola/Ames ADM must meet to be commercially viable. This input will be used by Motorola and Ames to meet commercial requirements where possible. The major medical monitoring company may be a potential Dual-Use partner for Phase 2: System Development, of the ADM development.

#### **Action**

RTI will assist Ames as needed in the continuation of the Motorola/Ames project and the continued relationship development with the major medical monitoring company.

**PROBLEM TITLE:**                    **Ultrasound Displacement Amplitude Measurement**

**SOURCE OF PROBLEM:**        **Technology Utilization Office, Langley Research Center**

**RTI PERSONNEL:**                **Molly O'Donovan Dix**

### **Background**

With expansion of the use of diagnostic ultrasound in recent years, there has been growing concern over the safety of ultrasound exposure, particularly with regard to the exposure of the fetus in utero. There is a good deal of research on the bio-effects of ultrasound and the development of reliable techniques to measure acoustic output from clinical diagnostic ultrasound equipment. The Food and Drug Administration (FDA) is promulgating new regulations to cover ultrasound equipment, and a new voluntary performance standard is being developed jointly by the National Electrical Manufacturers Association (NEMA) and the American Institute for Ultrasound in Medicine (AIUM). In the fall of 1989, FDA included their need in their draft document entitled *Research Agenda for the 1990s*.

Current measurement techniques use hydrophones constructed by polyvinylidene fluoride (PVDF) piezoelectric polymer. A response of hydrophones above 15 MHz is highly dependent on the nature of construction and film thickness, as well as associated preamplifier circuitry. Other factors that can affect measurement accuracy are the condition of the water medium, preamplifier dynamic range limitations, presence of shock fronts due to finite amplitude distortion, and spatial averaging due to the finite size of hydrophones. For these reasons, hydrophones must be calibrated to an NBS reference standard.

A technique to make accurately and reliably absolute measurement of ultrasound intensities is needed. The successful techniques must have a bandwidth of at least 50 MHz and have a focal diameter of approximately 1 mm.

### **NASA Technology**

NASA LaRC physicists have developed a measurement system based on the LaRC-developed electrostatic acoustic transducer (U.S. Patent No. 4,080,960). The device is inherently insensitive to the phase on the acoustic wavefront, has broad-band response, and is capable of following the envelope of typical diagnostic imaging pulses. An accuracy of better than 2.3 to 4 percent is reported in the range of 0.4 to 15 MHz.

### **Participants**

- Tom Yost, NASA LaRC

### Status

NASA LaRC has completed the prototype instrument and method for absolute measurement. The RTI Team assisted early efforts by providing pertinent literature, establishing contact with NEMA and AIUM, and evaluating the commercial potential. In 1991 RTI also supplied details on the electrostatic acoustic transducer and on the proposed project to FDA, NEMA, and AIUM.

In 1992 RTI's activities included contacting the National Institute of Standards and Technology (NIST), FDA Center for Devices and Radiological Health and AIUM. From each contact we requested technical review of the prototype's results as presented in a pre-print article by W.T. Yost. We have communicated these results to LaRC and developed a commercialization strategy in conjunction with LaRC.

In 1993 RTI developed a Technology Opportunity Announcement which described the technology and the commercialization opportunity. This opportunity sheet was sent to over 40 companies targeted as potential commercial partners. Six companies originally expressed interest in the technology.

A technology briefing was held on October 21, 1993 in conjunction with the Langley Technology Opportunity Showcase (TOPS). One company attended the briefing and three others requested additional information (including a videotape of the briefing). Follow-up packages were sent to all four companies on November 17, 1993. Both positive and negative responses were requested by the end of January.

### Action

Review responses of companies. Plan continued commercialization efforts based on these responses.



## 5.0 COORDINATION OF ONGOING PROJECTS

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**PROBLEM TITLE:** Contextual Alarm Management System (CALMS)

**SOURCE OF PROBLEM:** National Special Education Panel

**RTI Team Personnel:** Dean Hering, Dan Winfield

Technologies are needed to provide modularization, integration, and portability of medical monitors and life support units for children in order to reduce the management requirements of multiple system operation.

Due to medical advances and recent federal legislation, an increasing number of medically fragile children are in evidence in the public schools. The medical monitoring and life support needs of these children can be complex. As hospitals release these children to their families, both parents and school staff are required to learn to operate a variety of medical equipment usually found only in medical facilities. Monitoring devices include apnea monitors, devices which monitor heart rate, oxygen saturation, fluid retention, seizures, etc. Life support systems include those which provide nutrition, ventilation, suction, medical drips, dialysis, etc. Children are often connected to several such devices which are then transported to and from school and into the community on family outings. There is a need for a single, modular monitoring device which can incorporate multiple devices as needed in order to reduce the amount of equipment needed by an individual child and still meet the medical needs of that child. Additionally, parents and care-providers report that when alarms sound, they are sometimes unable to identify the source of the problem because the child has so many, similar sounding alarms and buzzers. A system which integrates these alarms and presents the information clearly to care-provider would greatly enhance the effectiveness of the equipment.

Several leading medical monitor manufacturers indicate that alarm management and coherent instructions for care-providers via displays on monitoring systems are of great interest to their industry and would provide worthwhile opportunities in the medical monitor device market sector.

### **NASA Technology**

The Biomedical Risk Assessment Intelligent Network (BRAIN) technology developed by KRUG Life Sciences for NASA Johnson Space Center was identified as a potential match for the problems specified in the problem statement. BRAIN is an artificial intelligence based system

## 5.0 COORDINATION OF ONGOING PROJECTS

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that uses a knowledge base to assess biomedical risks. Given medical monitor inputs and an appropriate knowledge base, researchers at KRUG and NASA feel that BRAIN can be adapted to provide an assessment of alarm conditions and interactions generated by multiple monitors.

### Participants

- Dr. Karin Loftin, KRUG Life Sciences
- Mr. Bill Norfleet, NASA JSC
- Dr. Jeff Feldman, Albert Einstein Medical Center
- Ms. Gayl Bowser, Oregon Department of Education
- Major Medical Monitoring Company (the company)\*

*\*For competitive reasons, this corporation requests their name to remain confidential. This company is a leading medical monitoring manufacturer with 1991 revenues exceeding \$180 million for their monitors.*

### Status

The Team held several teleconferences during which Dr. Feldman, Dr. Loftin, and Mr. Hering developed a project plan for developing a Contextual Alarm Management System (CALMS). CALMS is a generic alarm management system to detect and remove artifacts from medical monitor signals and utilize multiple monitor signals to determine and manage alarm situations.

The company sent a letter to JSC committing \$300,000 support to the project. RTI organized and participated in a project planning meeting at JSC in August at which the actual medical signals and conditions to be used for the prototype were finalized, roles and responsibilities were assigned, and the Project Plan initiated.

RTI coordinated several teleconferences between JSC Legal and the company legal to develop the Space Act Agreement. In January, RTI contacted Jack Mannix, NASA HQ Code G, who assisted Johnson Space Center and the corporate partner in arriving at a mutually beneficial intellectual property arrangement for the Contextual Alarm Management System Space Act Agreement. The Agreement was signed by the partner and sent to JSC legal on March 26, 1993. Following a series of reviews, the Space Act Agreement was signed by JSC in June 1993. Subsequent to this signing, the Company entered into a contract with Dr. Feldman to support his portion of the project. RTI participated in a project kick-off meeting at JSC in August 1993 to finalize task assignments and schedules.

### Action

RTI will monitor project progress.

**PROBLEM TITLE:**            **Convolver for Real-time Image and Signal Processing (CRISP)**

**SOURCE OF PROBLEM:**   **NASA-Langley Research Center**

**RTI Team Personnel:**   **Dean Hering**

### **Background**

Dr. Joseph Heyman, Chief of the Nondestructive Evaluation (NDE) Branch at Langley Research Center referred the Team to Mr. Daniel Perey, who is managing the CRISP project at LaRC. The CRISP, based on a novel digital signal processing technique, enhances the quality of real-time signals from a variety of measurement systems. LaRC uses the CRISP to improve signal resolution for aircraft inspection, composites NDE, structural damage measurements, and high temperature measurements.

Mr. Perey's group was interested in finding a commercial partner to team with the group in developing a hardware version of the current software implemented technology. Additionally, Mr. Perey's group was interested in determining what industry requirements should be included in a commercial instrument, both from a manufacturing and user perspective.

### **Participants**

- Mr. Daniel Perey, LaRC

### **Status**

The Team assisted in writing an announcement for the *Commerce Business Daily* (CBD) discussing the opportunity to work with NASA and the CRISP Workshop.

RTI and LaRC located and contacted potential industry partners to discuss the CRISP technology, solicit user requirements, and discuss the commercialization workshop. Brochures (developed by the Team) and additional information were provided to the contacts. Together LaRC and RTI contacted approximately 200 companies.

RTI travelled to LaRC on May 6, 1992 to participate in the commercialization workshop. Eleven representatives from nine companies attended. Several other companies unable to attend requested the video of the workshop to ascertain their interest in teaming with NASA.

## **5.0 COORDINATION OF ONGOING PROJECTS**

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LaRC received the commercialization proposals in August 1992. RTI assisted LaRC in reviewing portions of the proposals. LaRC selected two partners and contacted them to discuss commercialization.

ABB Amdata has been granted a license and cooperative work with LaRC has begun. Westdyn (formerly Dynacom) is awaiting final signature of their license to this technology.

### **Action**

Monitor project progress.

**PROBLEM TITLE:** Digital Mammography System

**SOURCE OF PROBLEM:** National Cancer Institute  
Diagnostic Imaging Research Branch

**RTI Team Personnel:** Daniel Winfield

### **Background**

In 1993 approximately 186,000 women will be diagnosed with breast cancer and 47,000 women die. In all, one in eight women can expect to be affected by breast cancer at some time during their lives. Screening and early diagnosis are currently the most effective ways to reduce mortality from breast cancer. The widespread acceptance of mammography as an important tool for the screening and early diagnosis of breast cancer has resulted in a proliferation of dedicated equipment and associated technologies. Nevertheless, there are several technical factors which limit the ability of film-based mammography to display the finest or most subtle details, and produce images with the efficient use of radiation dose to the patient. There is an increasing need to overcome the technical limitations, improve image quality, and, at the same time, satisfy the requirements for low radiation dose and cost effectiveness. There is no doubt that computer workstations combined with recent technological developments in direct digital x-ray detection systems, advanced image processing and pattern recognition methods, and customized very large scale integrated (VLSI) circuits hold a major part of the solution to the escalating demands of this medical imaging modality.

The National Cancer Institute has targeted digital mammography as a priority need and is working with the Technology Applications Team to locate the best available technologies under development within federal laboratories for application to this problem.

### **NASA Technologies**

Forty five responses were received from various federal labs including eighteen from NASA Field Centers. Following evaluation by NCI experts, the following technologies were selected for in-depth evaluation:

CCD-based imaging detectors (JPL, LaRC, MIT Lincoln Lab and U.S. Army Armament R&D Center)

Solid State Imagers with Scintillation Fibers (Lockheed and Nanoptics)

## 5.0 COORDINATION OF ONGOING PROJECTS

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High resolution, high brightness displays (National Information Display Lab)

Wavelet transforms for pattern recognition (LeRC)

Analog and digital VLSI implementations of image processing (JPL)

Pattern Recognition software (Naval Surface Warfare Center, Lawrence Livermore National Lab, and U.S. Air Force Wright Lab)

Image compression software and hardware (JPL and LeRC)

Cesium iodide scintillators in amorphous silicon (Lawrence Berkeley Lab)

Thin film detectors (Nova R&D)

All optical, tunable high speed networks (MIT Lincoln Lab)

### Participants

Dr. Faina Shtern

National Cancer Institute

Four scientific advisors to NCI

(Dr. L. Clarke, Univ of South Florida;  
Dr. M. Yaffe, Univ. of Toronto;  
Dr. J. Blaine, Washington Univ.;  
and Dr. K. Doi, Univ. of Chicago)

NASA participants to be determined

### Status

NCI scientific advisors visited several federal labs and contacted others by phone to discuss their technology expertise in image processing, pattern recognition, CCD detectors, and analog and digital VLSI implementation. These advisors completed their evaluation and the list of candidate technologies was narrowed to the above list.

Plans were initiated to conduct a workshop to accomplish two objectives:

1. More in-depth evaluation of the application potential of each technology.
2. Involvement of the medical device industry to begin forming partnerships for development.

The RTI Applications Team organized and chaired a Digital Mammography Workshop in Bethesda, MD on May 19-20, 1993. Invitations to industry invitees were coordinated through the National Electrical Manufacturers Association Division in Diagnostic Imaging. Over 90 people (including 28 industry reps) participated in the meeting which was unanimously judged a huge success. The format contributed greatly to helping participants assess the applicability of each of the candidate technologies. The results of the workshop were reported to the NASA-NIH Advisory Committee which responded favorably to this effort.

In September 1993, the NCI-NASA Work Group decided to issue a joint NCI-NASA Program Announcement for Federal Technology Transfer to Digital Mammography. The Program Announcement was written and received final approval in October; proposals will be due Feb. 1, 1994.

### **Action**

RTI will assist NASA Field Centers in putting together partnership proposals for this joint program. RTI will also support NASA HQ as needed in continuing management of this program.





**PROBLEM TITLE:** Early Language Intervention System (ELIS)

**SOURCE OF PROBLEM:** National Special Education Panel

RTI Team Personnel: Stephen Lehrman

### **Background**

An Intelligent Computer Aided Training system is needed to provide initial language instruction to young children at risk for developing disabilities and children who have not yet developed basic language skills and concepts. Recent legislation from the federal government puts an increasing emphasis on the early education of children with disabilities. The Individuals With Disabilities Education Act (IDEA) provides for early intervention in the education of children with disabilities from the age of three. Programs such as Head Start and state mandated programs for early intervention and education of children at risk for developing disabilities may serve children from the age of three months.

A primary focus of early intervention programs and special education programs for young children is the development of basic language and communication skills. Without a firm understanding of basic concepts, children will be unable to succeed in school programs. Education research has indicated that the use of computers with speech output to teach emerging language skills can significantly increase the language skills of young children with disabilities.

While a number of computer programs for teaching isolated language concepts and vocabulary items are available for use with children who are learning initial language skills, these programs are generally based on a drill and practice model. The programs present a series of questions to which the child must respond. While these questions may be presented in random order, the programs do not adjust the content of the tasks based on the responses of the child and are insensitive to the way the individual student learns. In addition, programs generally present "splinter" language skills in isolation. This bits and pieces approach does not provide the integrated approach necessary to smoothly develop a child's language skills. The quality of computer based language instruction is currently based on the ability of the educator to select appropriate software at the appropriate moment.

An Intelligent Computer Aided Training (ICAT) system with voice output and integrated language training using expert systems techniques to decide which skills to teach would extend the expertise of early intervention and special education teachers and help deliver timely individualized emerging language instruction. An ICAT system can compare a student's

## 5.0 COORDINATION OF ONGOING PROJECTS

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performance with a system model for the exercise, evaluate the student's progress and mastery, catch mistakes, provide extra practice in areas of difficulty, and provide feedback to guide the student in solving the problem correctly. This approach provides much more individual attention that students often miss in class or do not receive from conventional software packages.

The curriculum/rule base will be developed by or in conjunction with a panel of educators and speech therapists identified by the Special Education Panel. This problem is one of two identified by a National panel of special education practitioners convened by the Department of Education's Center for Special Education Technology. This panel is working with the Applications Team in a special initiative to apply technology to needs in special education. Researchers in NASA JSC's Software Technology Branch responded in February with an interest in using the ICAT system used by JSC for the Physics Tutor and an adult literacy tutor.

### **NASA Technology**

Researchers in NASA JSC's Software Technology Branch responded with an interest in applying the ICAT system used by JSC for training shuttle crews and ground personnel. The ICAT system is an expert system based platform that captures the knowledge of training staff for use in computer training systems. The system adjusts the exercises and training to the student's progress, providing more training in weak areas and less in strong areas, and provides an evaluation for the teacher. This approach allows the student to have instruction similar to a one on one session with a tutor.

By rewriting the rule base, capturing the knowledge of special educators and otherwise adapting the ICAT system to the special education environment, the same technology can be applied to help develop the early language skills of young special education students. The requirements for doing so involve locating a leading special education software company with successful products for the target age group, knowledge of teaching reading skills, and the manufacturing/distribution system for commercializing the technology.

### **Participants**

- Bowen Loftin, NASA JSC
- Bob Way, Computer Sciences Corporation (for NASA)
- Mary Wilson, Laureate Learning Systems
- Bernie Fox, Laureate Learning Systems

### **Status**

Johnson Space Center has delivered to Laureate Learning the animation software tools. These tools will enable Laureate to animate the different exercise scenarios. The animation tools will also be incorporated into many of Laureate's existing software products.

Johnson Space Center has begun working on the intelligent exercise selection modules. Based on the student profile, this module will choose which exercise to present to the student. Simultaneously, Laureate Learning is working on the instruction/exercise knowledge base.

In a related activity, Johnson Space Center has helped Laureate Learning port some of their more than 40 titles to the MacIntosh platform.

### **Action**

Johnson Space Center and Laureate Learning continue to hold regular telephone conference calls. Most business is conducted by fax, phone, and e-mail. After an early delay, project work appears to be on-schedule.



**PROBLEM TITLE:** Ice Detection and Thickness Measurement System

**SOURCE OF PROBLEM:** Johnson Space Center

**RTI Team Personnel:** Dean H. Hering, C. Gary Hughes

### **Background**

This project was pursued at the request of Dr. Dickey Arndt, Chief of JSC's Electromagnetic Systems Branch. Dr. Arndt's Branch performed research and developed, with NASA contractor Stolar Research Group, a laboratory demonstrable ice detection and thickness measurement system for use on the Space Shuttle's external tank. Dr. Arndt and his staff realized that the ice detection system offered a novel approach to ice detection which might interest outside groups. Such groups include the FAA, interested in new techniques to prevent accidents such as the several recent airplane accidents in Washington, DC., Denver, Colorado, and Europe caused by ice and snow build-up on aircraft.

The JSC sponsored sensor overcomes several problems plaguing current sensors, including the ability to perform accurate measurements when a layer of water or water-ethylene glycol (deicer) is present. The small size of the JSC sponsored ice detector also lends itself to flush mounting, eliminating the possibility of creating an additional icing surface on the aircraft.

### **Participants**

- Dickey Arndt, JSC
- Andrew Chu, JSC
- Larry Stolarczyk, Stolar Research Group, RIMtech
- Charles Masters, Federal Aviation Administration (evaluator/advisor)
- David Minsk, Strategic Highway Research Program (evaluator/advisor)

### **Status**

RTI assisted JSC and RIMtech with contacts and meetings with the Federal Aviation Agency, Strategic Highway Research Program, Department of Transportation, and the Federal Highway Administration. A number of articles resulted from this exposure and presentations at several conferences. After RTI completed a state-of-the-art review for aircraft and highway applications of ice detection systems, the way was cleared to put together a collaboration between the developers and JSC to grow the technology and bring it to a point where it could be brought to market. Industry committed 85% of the required funding (\$960,000) and looked to NASA for co-funding which would result in a 5.7 to 1 leverage of NASA funds.

## 5.0 COORDINATION OF ONGOING PROJECTS

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NASA funding for this work was approved for FY94. The Space Act Agreement was awarded to Raton Technology Research (RTR), a company spun off by RIMtech to develop the ice detection technology (now called KELVIN) and associated markets. Including FY93 money, JSC has committed to \$74,000 to the effort. FY95 funding is not yet firm. RTR has continued to develop the technology during the interim, prior to the Agreement. They have also continued to promote the technology in both aircraft and ground transportation markets.

Everything is on "go." Technical work is proceeding on design specs, displays, antenna design, microcircuit design and testing. Marketing activities are increasing and the RTR business plan is essentially complete. RTR is presenting a paper at Tech 2003 and there will be an article in the December *NASA Tech Briefs*. Many airline companies are showing keen interest.

### Action

RTI will monitor and document the project's progress, and assist in the initial project phase.

**PROBLEM TITLE:** Improved Prehensor Mechanisms for Myoelectric Upper Limb Prostheses

**SOURCE OF PROBLEM:** Limbs of Love Foundation (American Initiative)

**RTI Team Personnel:** Daniel L. Winfield

Innovative approaches from robotics and related fields are needed to provide more degrees of freedom in thumb, wrist and/or finger motion to achieve more functional prehension (grasp) in myoelectrically controlled hand prostheses. There are approximately 100,000 arm amputees in America today, of which 10% are under age 21. Approximately 300 children per year are born without a hand and an additional 200 per year lose hands as a result of trauma. There are two general types of prosthetic arms in use: (1) body-powered shoulder harness and (2) myoelectric (battery powered, controlled by electrical signals from muscles). In either case, hands are limited to one active degree of freedom, e.g. opening and closing of a hook. Despite such rudimentary technology, a myoelectric arm prosthesis will cost between \$6,000 and \$14,000. Maintenance costs are significant as well (typically about 10% of original cost per year) due to less than desired reliability in the electronics and due to wear and tear on the materials. For children who will outgrow a prosthesis every 12-18 months, the on-going cost can be quite substantial. In addition, no myoelectric hands for children are currently produced in the United States.

Recognizing many areas of potential technical advancement, RTI has worked with Johnson Space Center and the Limbs of Love Foundation in a new initiative to identify opportunities to apply advanced technologies toward a next generation myoelectric hand to be manufactured in the United States. The Limbs of Love is a private, consumer-oriented foundation which procures myoelectric prostheses for children in need, and more recently has become interested in seeing prostheses developed with improved capabilities, increased reliability and reduced costs. A number of needs have been identified and are summarized in a report of a workshop held at Johnson Space Center during 1991. Copies of this report are available for those wishing more information.

### **NASA Technology**

Project will apply NASA technology in robotics (dexterous manipulators, tactile sensing, control systems), materials, and electronics. Includes both in-house R&D and work performed under current SBIR contracts.

## 5.0 COORDINATION OF ONGOING PROJECTS

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### Principals

- Cliff Hess, NASA Johnson Space Center
- John Combs, Limbs of Love Foundation
- Diane Atkins, The Institute for Rehabilitation Research (TIRR)
- Ian Walker, Rice University

### Status

RTI and JSC provided input to Baylor College of Medicine for their proposal to the National Center for Medical Rehabilitation Research (NCMRR), including information on various NASA R&D and relevant SBIR contracts. Also, RTI prepared a problem statement summarizing the need for more durable cosmetic gloves for covering the prosthetic hand. RTI attended an NCMRR-sponsored conference on Prosthetics and Orthotics, July 23-25, 1992 to learn more about the priority needs and to explore possible co-funding mechanisms.

The NCMRR decided to fund only Phase I of the Baylor proposal. This Phase is to conduct a survey of prosthetic arm user needs. Once the survey is complete, we will have a better definition of the needed technology developments.

Oceaneering Space Systems (OSS), a NASA contractor, became interested in this subject and approved an IR&D project to study the requirements in light of their technical capabilities.

### Action

RTI will continue to work toward a cooperative project between Baylor, OSS, and NASA JSC. This will likely depend on funding availability from NCMRR for Phase II.



**PROBLEM TITLE:** Measurement of Cleanliness of Printed Circuit Boards

**SOURCE OF PROBLEM:** National Center for Manufacturing Sciences

**RTI Team Personnel:** Stephen A. Lehrman

### **Background**

New instrumentation is needed to perform repeatable, quantitative measurement of contaminant type and quantity on printed circuit boards.

The National Center for Manufacturing Sciences has initiated a project titled *Definition and Measurement of Clean - Electronic Components*. The project team consists of representatives from Texas Instruments, Ford, AT&T, General Motors/Delco, General Motors/Hughes, and Sandia National Laboratory. The purpose of this project is to develop an industry standard test method and the associated instrumentation to measure organic and inorganic residue contaminating the surface of printed circuit boards. The end goal of the project is to develop an online, assembly line, inspection system for acceptance of finished boards.

### **NASA Technology**

Optically Stimulated Electron Emission (OSEE) is a nondestructive, noncontact surface contamination detection system capable of detecting thin layers of contamination on conducting surfaces. OSEE equipment has been used to inspect solid rocket motor critical bonding surfaces for contamination. The OSEE phenomenon, which uses photoelectron emission, is caused when ultraviolet light is incident on the specimen surface. Photoelectrons released from the surface are measured. The signal from the surface may increase or decrease depending on the type and thickness of the contaminant. Sensitivity measurement needs to be performed for each type of contaminant. Marshall Space Flight Center and Langley Research Center have worked with OSEE.

### **Participants**

- Tom Yost, NASA Langley
- Chris Welch, NASA Langley
- Mike Wixom, NCMS
- Carole Ellenberger, Texas Instruments
- Urmi Ray, AT&T Bell Labs

## **5.0 COORDINATION OF ONGOING PROJECTS**

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### **Status**

Dr. Chris Welch and Dr. Tom Yost successfully demonstrated that OSEE could discriminate contaminants on non-conducting surfaces. Langley developed a dose-response curve for the insulating portion of the printed circuit board. The industry participants concluded that OSEE was sensitive enough to provide a quantitative measurement of surface cleanliness. Drs. Welch and Yost reported their findings in a paper presented at the American Society for Nondestructive Testing annual meeting in March, 1993. These results led to Langley Research Center filing a patent application in May titled "A quality monitor and monitoring technique employing optically stimulated electron emission."

Langley submitted a proposal to NCMS for funding to continue the investigation. Because this proposal was the first of its kind between NCMS and NASA, it has required significant legal review. A major point of negotiation has involved rights to intellectual property developed during the NCMS-funded investigation. As of this date, no final resolution has been reached. It is hoped that the final agreement will be negotiated and signed by the end of the year.

### **Action**

Negotiation between NASA and NCMS is being handled by the Langley Technology Utilization and Patent Counsel offices. The Applications Team continues to monitor the negotiations.

**PROBLEM TITLE:** Medical, Electrolytic Oxygen Concentrator

**SOURCE OF PROBLEM:** Florida Solar Energy Center

**RTI Team Personnel:** Daniel Winfield

### **Background**

It is estimated that 2 to 4 million cardiopulmonary patients in the U.S. require supplementary oxygen; approximately 500,000 patients require continuous oxygen therapy. Current means to supply oxygen include compressed oxygen cylinders (heavy and expensive); liquid oxygen (cryogenic and expensive); and sieve-bed oxygen concentrators (heavy and bulky). While many patients can be served with oxygen concentrators which use the molecular sieve technology, weight, size and power requirements for these systems preclude their ambulatory application. People are forced to turn to the gaseous or liquid oxygen, but these technologies suffer from several drawbacks. Both are relatively expensive and require delivery of replacement cylinders or canisters. They provide a limited supply of oxygen, and thus cannot be used for extended periods. Gas cylinders are heavy and liquid oxygen canisters require cryogenic storage.

Demand cannulas have been introduced in recent years which reduce the flow rate requirements. This allows an oxygen cylinder to last longer during ambulatory use. However, these cylinders are still heavy, rather expensive, and require delivery from a gas cylinder supplier. The subject project seeks to provide an ambulatory oxygen concentrator which provides a reduced flow rate for use with demand cannulas. Progress is needed to reduce size, weight, and power requirements.

### **NASA Technology**

NASA has supported work at Kennedy Space Center investigating electrolytic processes for oxygen extraction from the atmosphere. In 1991, NASA supported R&D at the Florida Solar Energy Center (FSEC) developing the basic technology for a solid polymer electrolyte system. The solid polymer electrolytic oxygen concentrator (SPEOC) will ultimately address the above limitations and may lead to the first truly portable oxygen concentrator for home medical use. The SPEOC electrochemically extracts oxygen from air at near ambient pressures and temperatures. With the advent of modern polymers capable of a high degree of ion conductivity and process resilience, it is now possible to perform electrolysis in solid membranes (e.g., perfluorinated sulfonate ionomers). Based on work conducted for Kennedy Space Center, FSEC researchers have built a small prototype SPEOC unit and are experimenting with approaches to increase current density and thus efficiency of oxygen transport.

## 5.0 COORDINATION OF ONGOING PROJECTS

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### Participants

- Ali T-Raissi, Florida Solar Energy Center
- Mike Lonergan, NASA Kennedy Space Center
- George Cavagnaro, Healthdyne Technologies, Inc.

### Status

On initiation of the project in 1991, a start-up company was involved for commercialization of the technology. However, that company has since dropped from the project due to inability to negotiate a license agreement with the FSEC. Recognizing the need for a commercialization plan, NASA KSC asked the Applications Team at RTI to assist in securing a commercial partner for this project. RTI worked with the principal investigator at FSEC to develop a technology opportunity announcement summarizing the technology, its application, and current development status. This announcement was mailed to eighteen companies in the respiratory therapy market. Eight companies expressed active interest, and three have visited FSEC. RTI assisted FSEC in developing a detailed project plan and funding estimates. Negotiations are now complete with Healthdyne Technologies, a leader in the medical oxygen concentrator market, agreeing to project cost and co-funding schedules. In return for their financial support, Healthdyne will receive an exclusive license to the technology. In addition we have involved the Florida Technological Research and Development Authority (TRDA) in the most recent meeting with Healthdyne, TRDA has tentatively agreed to match any future NASA funding amounts.

Upon review of the legal agreement between Healthdyne and the Univ. of Central Florida (UCF), UCF determined that two documents were required: a research agreement and a licensing agreement. Following delays as Healthdyne Technologies was taken public, these revised agreements have been prepared and signed by both parties.

### Action

RTI will monitor further project progress.

**PROBLEM TITLE:** Powder Curtain Prepreg Process

**SOURCE OF PROBLEM:** NASA-Langley Research Center

**RTI Team Personnel:** Stephen Lehrman

### **Background**

Thermoplastic composites offer the potential of more attractive mechanical properties at elevated temperatures than do other materials. The primary concern in achieving this potential has been the difficulty experienced in combining thermoplastics with continuous fiber tows to produce a composite prepreg material.

Many previous methods of applying polymer matrices to filamentary materials to produce composite prepregs have been attempted. These methods include slurry coating, coating from solvent based matrices, film coating and calendaring. The primary problem with most of these methods is the non-uniform distribution of the polymer materials through the filamentary materials. A second problem associated with these methods is the removal of certain species of carrier material in the polymer matrix at subsequent processing steps.

### **NASA Technology**

NASA Langley Research Center has developed and patented a process for the uniform application of polymer powder resins to a filamentary tow in a continuous process to form a uniform composite prepreg. The patented technology involves an improved method for spreading the fiber tow and impregnating the tow with resin via a fluidized bed process to produce a uniform prepreg material. Advantages of this system over current methods are the elimination of the use of solvents and the predictable, uniform prepreg materials produced.

Langley Research Center has built a prepreg machine able to produce 12000 linear feet per day of single tow (1/8 inch) prepreg. The equipment can be modified to handle a multiple tow system. Almost any resin system supplied in powder form can be used.

Langley Research Center requested RTI's assistance in evaluating the commercial market for the equipment. RTI performed the evaluation and identified sixteen companies that may be interested in licensing the patent or co-sponsoring further development.

## **5.0 COORDINATION OF ONGOING PROJECTS**

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### **Participants**

- Bob Baucom, NASA Langley Research Center

### **Status**

The Applications Team worked with the Langley Technology Utilization Office to identify potential licensees for the technology. The Team contacted the Society for the Advancement of Materials and Process Engineering which provided a list of the major prepreg materials producers. Using the Thomas Register and Corp Tech directories, the Team identified and screened more than 20 companies that either made prepreg manufacturing equipment or prepregs. The Team worked with Langley to develop a brochure describing the powder curtain prepreg technology and mailed the brochure to the selected companies. Electrostatic Technologies of Massachusetts and Polymer Composites, Inc. of Minnesota submitted to Langley information describing their use for the technology and business intentions. These companies were invited by Langley to a commercialization workshop in July. Both companies visited Langley and met with Mr. Baucom. Both companies were given information on submitting a technology transfer and commercialization proposal to Langley. As of this date, neither company has submitted a proposal.

### **Action**

The Applications Team needs to recontact Electrostatic Technologies and Polymer Composites and assess their commercialization interest.

**PROBLEM TITLE:**                    **Optical Shutter Switch Matrix**

**SOURCE OF PROBLEM:**        **Kennedy Space Center**

**RTI Team Personnel:** **Dean Hering**

### **Background**

Data processing and peripheral support systems, ground telemetry stations, aerospace vehicles, satellites, telecommunications systems, televideo systems, and other information rich systems demand improved interface and switching performance. Industry and government agencies rely heavily on video, data, instrumentation, communications, processors, and computer systems to perform day to day and critical activities. The interface switching system technologies needed to meet today and tomorrow's system performance must be developed if large scale systems are to be manufactured.

The Kennedy Space Center's Shuttle Launch Processing System (LPS) alone supports 250 work stations, 350 minicomputers, 2 mainframes, 27 computer simulators, and over 2,000 peripheral equipment systems comprising magnetic disk, analog and digital tape units, printers, plotters, and graphic recorders. Tens of thousands of copper cables, switch panels, numerous digital and analog switching systems, and transmission line conditioning equipment must be replaced to meet increasing communication needs. Similar needs exist in the telecommunications industry.

Current systems based on reed relay technology, TTL logic, MOS analog switches and amplifiers, digital multiplexers, and logic arrays contain shortcomings preventing them from meeting the needs of the equipment. Additionally, with fiber optic cable replacing copper, the need to translate optical signals to electric and back during switching promote unacceptable delay and bandwidth limitations. User requirements drive the need for next generation systems based on all optical switching technologies. Commercial systems do not yet exist to meet this challenge.

### **NASA Technology**

Researchers at NASA Kennedy Space Center have patented and contract tested an Optical Shutter Switch Matrix which combines mature and newly developed optical technologies into a simple, small, low-power, light-weight, low-cost manufacturing package. The OSSM allows any of number of input optical fibers to be switched to any of a number of output optical fibers. Any input can be switched to any output by electronic or optical activation of the transmissive optical shutter cell.

## 5.0 COORDINATION OF ONGOING PROJECTS

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KSC contracted a feasibility study which was completed in March 1990. A 6 by 6 prototype matrix was constructed and tested to identify any manufacturing limitations and establish preliminary performance benchmarks.

KSC requested RTI's assistance in teaming with a commercial partner to further develop the switch for commercial and KSC use.

### Participants

- Charles H. Grove, NASA Kennedy Space Center
- J.J. Pan, Advanced Optronics
- Bob Fields, Advanced Optronics
- Michael Sobek, SPRINT

### Status

RTI discussed the OSSM with contacts at AT&T, TRW, SPRINT, and Electronic Data Systems as initial telecommunications contacts; contacted BroadBand Technologies, ITT Canon, and Scientific Atlanta as initial cable service and cable TV contacts; and discussed the technology with Physical Optics Corporation and Optivision as reviewers in the technical area of OSSM.

SPRINT responded with an interest in applying the OSSM to three optical fiber networks: MAGIC, a ARPA sponsored network for real time supercomputing use of satellite data, the NASA/DOE High Performance Computing and Communications (HPCC) Program network portion recently awarded, and a K-12 educational network linking students with the EDOS database. SPRINT operates a Gigabit test bed for testing new technologies for these networks and believes the OSSM may provide a network management technology key to reliability, survivability, and crossconnectivity.

RTI coordinated several teleconferences between SPRINT, KSC, and Advanced Optronics (the developer of the first OSSM for KSC). The parties have defined the specifications for the switch for SPRINT to test in the testbed. Advanced Optronics and NASA KSC will next define the resources necessary and in place to develop the switch. From that a project plan will be developed.

RTI also contacted the NASA contract monitor for the NASA/DOE HPCC contract to SPRINT (who is at Ames Research Center) and the contract monitor at ARPA for the MAGIC network. Both are interested in the project and wish to be contacted as the project is defined further.

Advanced Optronics defined the resources necessary and in place to develop the switch to the specifications indicated by SPRINT. Based on that definition, which requires more funding than



is available in KSC's budget, RTI contacted ARPA and NASA/DOE to ascertain their interest in participating. NASA/DoE declined to participate; ARPA declined as well.

### **Action**

This project will be considered by KSC for a Technology Reinvestment Project in conjunction with the Florida Technological Research and Development Authority. RTI will assist KSC in pursuing that opportunity.

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**PROBLEM TITLE:** Rotating Cell Culture Vessels

**SOURCE OF PROBLEM:** NASA-Johnson Space Center

**RTI Team Personnel:** Daniel L. Winfield

Many biomedical studies and clinical applications require the culturing of specific cell types. Current cell culture technology has a number of limitations. While certain cell types can be grown to proliferation, other types are very difficult to grow and/or very slow to proliferate. In addition, when cells proliferate in a Petri dish, they flatten out in a laminar fashion and exhibit few of the three dimensional intercellular structural features seen in the human tissue counterpart. For many applications, it can be expected that a cell culture method that produced more cells which closely resemble tissue structures would be highly valuable. This will allow improved means to test therapeutic drugs (e.g. chemotherapy for certain tumor types) and may eliminate the need for animal models in many areas.

#### **NASA Technology**

As a part of NASA's space bioprocessing research, JSC has developed horizontal cell culture vessels which rotate as a means to simulate the lack of sedimentation that occurs in microgravity. On Earth, JSC researchers have used these rotating cell culture vessels to grow a variety of heretofore difficult-to-culture cell types. In addition, three dimensional tissue masses resembling polyps have been cultured. This new method offers tremendous potential in numerous biomedical areas.

#### **Status**

Patents have been obtained by JSC and licensed to a new start-up company called Synthecon. In response to an RTI-circulated request, JSC submitted technical information which RTI forwarded to the American Cancer Society. ACS received three project concepts from potential collaborators to pursue one or more cancer applications of the technology. ACS has invited each to submit proposals for a one-year demonstration project. JSC has allocated funding for FY92. Dan Winfield discussed this technology on NASA Select TV at Technology 2001. RTI met with JSC and Synthecon to iron out details in the project plan. Based on these discussions the plan has been revised to cover funding and effort for only one year. This should be sufficient to assist the licensee in adapting the technology for the commercial market.

Synthecon has designed and developed culture vessels to improve the concept for testing at the Texas Medical Center. RCCVs are available for sale and Synthecon has signed an agreement with a European firm for European distribution.

**Action:** Project complete.

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**PROBLEM TITLE:** Treatment of Wastewater Containing Nonionic Surfactants

**SOURCE OF PROBLEM:** American Society of Mechanical Engineers and  
Independent Lubricant Manufacturers Association

**RTI Team Personnel:** Stephen Lehrman

The metalworking industry uses oil-water emulsions and cleaners in applications such as machining, grinding, parts washing, floor scrubbing, etc. Higher quality emulsions (for better stability and longer life) are now commonly used to reduce the volume of wastewater. Nonionic surfactants used in these formulations are difficult to treat and remove from the wastewater.

Typical oil-water emulsions, such as soluble oil, semisynthetic, and synthetic metalworking fluids, use anionic surfactants as the basic chemistry for most formulations. Chemical treatment methods such as neutralization and coagulation are effective in treating wastewater containing anionic surfactants prior to sewer discharge.

Nonionic surfactants can be used in small proportions to stabilize emulsions. Ethoxylated alcohols, ethoxylated alkyl phenols, aliphatic polyethers, and glycol ethers are commonly used as nonionic surfactants. These materials are difficult to chemically treat in wastewater due to their extreme water solubility.

### **NASA Technology**

Dr. Ted Wydevan of NASA Ames Research Center has modified a batch mode supercritical water oxidation reactor to perform research on the need to remove soaps and detergents from wastewater for long duration manned space flight. Ames plans to study the removal of nonionic surfactants from wastewater in the future.

### **Participants**

- Dr. Ted Wydevan, ARC
- Marle Hightower, ARC
- Phil Darcy, U.S. Army Watervliet Arsenal
- Ray Dick, Cincinnati Millicron

## **5.0 COORDINATION OF ONGOING PROJECTS**

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### **Status**

The Technology Application Team presented the proposed project to the Independent Lubricant Manufacturers Association R&D committee. The presentation was made at Argonne National Laboratory. Dr. Ted Sydevan and Mr. Mark Hightower of Ames Research Laboratory participated by telephone. ILEA has agreed to provide in-kind support in the estimated amount of \$25,000. The in-kind contribution consists of

100 Hrs. from Cincinnati Milicron  
50 Hrs. from Castrol  
\$1500 Material

### **Action**

The Applications Team needs to confirm in writing ILEA's contribution. Ames Research Center needs to prepare a project plan.

The Army has had recent discussions with the Department of Energy. Energy is offering the Army a 500 gallon/day continuous flow reactor for demonstration testing at Watervliet. In light of this new development, the Applications Team, Ames, and the Army need to reassess NASA's contribution to the project.

**PROBLEM TITLE:** Smart Sensing Technology Predictive Response Method

**SOURCE OF PROBLEM:** Technology Development Program  
John C. Stennis Space Center (SSC)

RTI Team Personnel: Molly O'Donovan Dix

### **Background**

At the request of Mark Mick, Technology Utilization Program Manager at SSC, RTI has assisted SSC in commercialization of the smart sensing technology and the predictive response algorithm it employs. A Fugitive Gas Detection System was developed by engineers at Sverdrup Technologies (SvT) for NASA. The predictive algorithm, which is the basis of the system, was developed to attain a rapid and accurate response from the best commercially available hydrogen sensor. SSC recognized several potential commercial applications for the algorithm, as well as the commercial value of the complete Fugitive Gas Detection System. Specifically, any innately slow sensor that provides a step output can utilize the predictive method to increase the sensor's speed of response. Potential applications include detection of gases other than hydrogen and digital electronic thermometers for humans and animals.

### **NASA Technology**

The primary benefit of the SSC technology over commercially available products is the combination of attributes it provides. No commercial sensors were found which could provide the speed of response, rugged nature, accuracy and reliability for which the SSC system was designed. The Fugitive Gas Detection System is a complete management system with advanced display characteristics. The menu-driven system provides facility schematics for quick location of leaks and can be used for system calibration and maintenance.

### **Participants**

- William L. Nail, Sverdrup Technologies
- Thomas L. Koger, Sverdrup Technologies
- Vivien Cambridge, Sverdrup Technologies

### **Status**

SSC contacted the Team with a request for a market assessment and a recommendation on how to pursue commercialization of the predictive method. RTI reviewed the material presented by SSC and contacted sensor experts. RTI presented SSC with the information gathered during the market research and requested clarification on the patent status before continuing.

## 5.0 COORDINATION OF ONGOING PROJECTS

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Following review of the market research by SSC, both RTI and SSC agreed that commercialization should be pursued without a patent and that a patent should be applied for if a commercial partner and a specific application are identified.

RTI developed three Technology Opportunity Sheets to aid in contacting potential commercial partners. The first sheet identified the Fugitive Gas Detection System and the predictive method it employs, the second was tailored to companies interested in application of the algorithm to digital electronic thermometers and the third was a general description of the predictive method as it could be applied to numerous sensor applications. The Technology Opportunity Sheets were used by SSC and RTI to discuss the Smart Sensor Technology with prospective partners. The sheets were also used at Technology 2002.

RTI identified and contacted IVAC, a major medical products company, as a potential partner to commercialize the SSC algorithm as part of their electronic thermometer. Conversations have been in process with IVAC since October 1992. In early March a Nondisclosure Agreement was signed between IVAC and NASA. Technical review of the application by SSC and IVAC resulted in a desire by both parties to continue forward with the application of the SSC predictive response algorithm to the IVAC electronic thermometer. The team scheduled and attended a meeting at IVAC with SSC on June 30, 1993. The meeting resulted in the definition of a Phase I project to develop a proof of concept system. Specifically, this system must:

- A) respond (in mouth) in less than 10 seconds
- B) utilize IVAC's temperature probe and cover
- C) have a clinical accuracy equal to the existing system
- D) utilize a PC-based, commercially available data acquisition system
- E) result in a design capable of being converted to producible product

RTI assisted in the development and review of a draft agreement between NASA and IVAC. There is great confidence that the final agreement will be signed by both parties.

### Action

Three months after final signatures of the Space Act Agreement the SSC/IVAC project is scheduled to be completed.



## 6.0 ADD-ON TASK STATUS

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This section presents the status of tasks added to the basic contract NASW-4367. The following add-on tasks were completed prior to this reporting period:

- TASK 1: AdaNet Program Support
- TASK 2: CAD/CAM for Custom Orthopedic Shoes
- TASK 3: Optimization of the Parameters of the Rotating Reactor
- TASK 4: JSC Outreach Program

The following tasks were active during the reporting period and are discussed in this section.

- TASK 5: Spinoff Technology Application Retrieval System (STARS)
- TASK 6: Planning and Analytical Support to NASA for the National Technology Transfer Center Program Development
- TASK 7: Technology Transfer and Commercialization Assistance to the Kennedy Space Center
- TASK 8: Outreach Materials and Activities to Promote NASA Applications Engineering and the Technology Transfer Process



**Task 5: Spinoff Technology Application Retrieval System (STARS)**

**Task Leader:** Ronnie Lashaw  
**Start Date:** November 1991  
**Completion:** July 1994

**Background**

NASA's Office of Commercial Programs (now the Office of Advanced Concepts and Technology) initiated a request for RTI to develop a prototype, database system for the storage and retrieval of NASA Technology Spinoffs information. The basis for these Spinoffs is found in the Spinoff magazine. The name for this system has been designated as STARS (Spinoff Technology Application Retrieval System).

**Objectives**

The purpose of this task is to support NASA Headquarters Office of Advanced Concepts and Technology in meeting the following objectives: 1) providing the public with a friendly, intuitive, and useful method for retrieving information about the secondary benefits of NASA Technology, and 2) providing NASA administrative personnel with a tool for responding to inquiries, preparing reports and speeches, and providing educational outreach material concerning NASA Technology Spinoffs. In this effort, RTI will work with NASA Headquarters to specify the requirements for the STARS system, both hardware and software. RTI will generate various prototype designs for review by NASA and will assist NASA in determining the best configuration of hardware and software for the system.

**Status**

STARS is a multimedia, relational database management information system designed to meet the following objectives:

- 1) Provide the public with a friendly, intuitive, and useful method for retrieving information about the secondary benefits of NASA Technology, and
- 2) Provide NASA Administrative personnel with a tool for responding to inquiries, preparing reports and speeches, and providing educational outreach material concerning NASA Technology Spinoffs.

RTI has completed STARS development activities funded under this add-on task including the benefits analysis being performed by Chapman Research Group. Several hardware and software prototypes were designed, generated and tested. STARS has been converted from a database-

only to a multimedia database supporting still images and audio/video input from a VCR and/or laserdisc players.

Additional funding has been provided for maintenance support of the installed base of the STARS application and to improve performance and functionality as specified by NASA HQ. Areas to be addressed include: congressional districts, keywords, 1992 Spinoffs, and software updates.

STARS has received widespread exposure at various national and regional meetings and has been installed at various locations for both NASA and public use.

### **Technology Tracking System (TechTracS)**

#### **Background**

NASA's Office of Advanced Concepts and Technology (OACT) Commercial Programs initiated a request for RTI to enhance and distribute a technology database initially developed for NASA Kennedy Space Center. The primary use of the database is for tracking new technology being generated by research from NASA employees and government contractors. The name for this system has been designated as the Technology Tracking System (TechTracS).

#### **Objectives**

The purpose of this task is to support NASA Headquarters OACT in meeting the following objectives: 1) Deploying a information system that is capable of tracking new technology from the point of being reported to the point of being licensed, 2) providing NASA Field Center personnel with a productivity tool that can generate correspondence between inventors and contractors. In this effort, RTI will work with NASA Headquarters and appropriate Field Centers to specify requirements for TechTracS.

#### **Status**

RTI has completed all TechTracS development activities funded under this add-on task. Those task include the following: 1) Development, installation and training of TechTracS at Langley Research Center (LaRC) , Ames Research Center (ARC), and Johnson Space Flight Center (JSC), 2) Importing of existing Tech Transfer data from LaRC, ARC, and JSC, and 3) Documentation.

**Action**

In the first quarter of FY 94, RTI will discuss with NASA HQ further development of TechTracs and installation at additional Field Centers and HQ. NASA General Patent Counsel (Code G) and the Patent Counsels at the NASA Field Centers have requested installation of TechTracs for their use.



**Task 6: Planning and Analytical Support to NASA for the National Technology Transfer Center Program Development**

**Task Leader:** Doris Rouse  
**Start Date:** November 1991  
**Completion:** July 1994

The purpose of this task is to provide selected planning and analytical activities in support of the NASA program development and management of the National Technology Transfer Center (NTTC). RTI will assist NASA and the NTTC in the development and refinement of cost-effective approaches for NTTC in its role of serving as a technology transfer link between industry and federal agencies. This support will include periodic analysis of NTTC program plans and reports and providing planning recommendations.

**Status**

RTI support to NASA HQ's Program planning and analysis of the National Technology Transfer Center activities in the reporting period has been:

- Participated in an NTTC Planning Session at NASA Headquarters on January 26, 1993. Topics discussed in the meeting included:
  1. Status of the Fund for Strategic Partnering
  2. Development of a METRICS program at NTTC
  3. Status of Gateway operations
  4. NTTC training division plans
- Assistance to NASA HQ in developing key issues for consideration in the NTTC 2 year plan.
- Classification of NASA Spinoffs by Critical Technology area.

**Action**

- Provide input to NTTC and NASA HQ on key considerations for training programs for Field Center staff. Evaluate approaches for computer-based training.
- Continue assistance to NASA HQ in planning activities.

1. The first part of the document is a letter from the President of the United States to the Congress, dated January 3, 1862.

2. The second part is a report from the Secretary of the Treasury, dated January 10, 1862.

3. The third part is a report from the Secretary of the Interior, dated January 15, 1862.

4. The fourth part is a report from the Secretary of the Navy, dated January 20, 1862.

5. The fifth part is a report from the Secretary of the War, dated January 25, 1862.

6. The sixth part is a report from the Secretary of the State, dated February 1, 1862.

7. The seventh part is a report from the Secretary of the Army, dated February 5, 1862.

8. The eighth part is a report from the Secretary of the Navy, dated February 10, 1862.

9. The ninth part is a report from the Secretary of the War, dated February 15, 1862.

10. The tenth part is a report from the Secretary of the State, dated February 20, 1862.

11. The eleventh part is a report from the Secretary of the Army, dated February 25, 1862.

12. The twelfth part is a report from the Secretary of the Navy, dated February 28, 1862.



**Task 7: Technology Transfer and Commercialization Assistance to the Kennedy Space Center**

**Task Leader:** Doris Rouse  
**Start Date:** January 1992  
**Completion:** July 1994

**Background**

This task is to provide a focused effort at the Kennedy Space Center to achieve expanded results in accomplishing two objectives: (1) developing agreements for joint participation in the technology transfer process and (2) providing a closer link to Kennedy technologists to identify new technologies with potential for transfer to the user community. RTI will assist KSC in developing linkages with external organizations and prepare draft agreements. RTI will also assist in review of technical progress in KSC technology development programs to ferret out new advances in technology that may be transferrable to the private sector. Finally, RTI will assist in assuring that new technology is incorporated into the KSC Technology Utilization Office records for quick access and processing for potential technology transfer purposes.

**Status**

The support to the NASA Technology Transfer Program at the Kennedy Space Center (KSC) consisting mainly of managerial, technical and administrative assistance in transferring technology, includes the following activities in FY93.

- KSC's Annual Report for 1992 was prepared for incorporation into the NASA Annual Technology Transfer Report required to be submitted to Congress under the Stevenson-Wydler Act of 1980. This 10-page KSC report shows that RTI's support for processing new technology items has resulted in a substantial increase in the publication of Tech Briefs, from 7 in 1991 to 32 in 1992, which in turn prompted a four-fold increase in industrial inquiries, going from 1,132 to 4,492 for one year.
- Support was further provided to the Technology 2002 Conference in Baltimore where KSC participated with five technical paper presentations and eight different technology exhibits. Briefings and assistance were given to approximately 2,000 conference attendees who viewed these exhibits. All of the arrangements for shipping and setting up these exhibits were also handled by RTI.

## 6.0 ADD-ON TASK STATUS

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- Initiated the Universal Signal Conditioning Amplifier project under the TRDA/NASA-KSC Dual Use Technology Partnership. TRDA is the Florida Technological Research and Development Authority. Prepared the Announcement of Opportunity and the proposal preparation guidelines.
- Initiated the Supersonic Air/Gas Cleaning System project under the TRDA/NASA-KSC Dual Use Technology Partnership. Prepared the draft Announcement of Opportunity.
- Identified and evaluated ten KSC technologies having potential for commercialization. These technologies were also included in the TRP proposal to ARPA on the TRDA/NASA-KSC Dual-Use Technology Partnership. Assisted TRDA in preparing a TRP proposal to ARPA.
- Prepared a Space Act Agreement between the State of Florida and NASA-KSC in regard to technology transfer. The agreement was staffed to the appropriate KSC and Florida organizations.
- Prepared a software distribution agreement of the copyrights and an assignment on the GPSS Software.
- Reviewed the Sensor System for a Robotic Arm, developed by Merritt Systems, Inc., for a potential technology transfer project. This project was proposed to the NTTC by TRDA with KSC being a partner.
- In regard to new technology reporting and contract data, the following activities were accomplished:
  - 65 reportable items received and processed
  - 35 reportable items screened and rejected
  - 71 items evaluated
  - 31 items processed for publication
  - 55 TSPs forward for preparation
  - 223 inquiries answered
  - 14 problem statements evaluated
  - 41 new contracts established for monitoring
  - 45 certifications of compliance were produced
- 36 abstracts were submitted to Headquarters in response to the Technology 2003 Call for Papers. Eight papers were selected for presentation.

**Task 8: Outreach Materials and Activities to Promote NASA Applications Engineering and the Technology Transfer Process**

**Task Leader:** Michael Hackett  
**Start Date:** January 1992  
**Completion:** July 1994

**Background**

This task is to develop outreach materials and activities to enhance applications linkages with industry and other user groups and develop effective means for addressing opportunities identified. Materials will be used for conferences, workshops, corporate interactions, etc. Activities will include preparation of slides and written materials describing the NASA Technology Transfer Program; maintenance of a visual resource library; and assistance to NASA in outreach activities.

**Status**

The following activities were completed during FY 93.

- Updated the NASA Technology Transfer Network flyer (which has since gone to print, twice) and developed a "quick and dirty" two-color, four-page (front-back, front-back) brochure on NASA's Technology Transfer Program (still waiting for approval to go to print). Also developed an RTTC flyer (including affiliates).
- Developed an initial outline of modules for a NASA slide/resource library.

**Technology 2002**

- RTI's Washington office played a major role in planning and coordinating the symposia and other activities for the Technology 2002 Conference and Exposition, working closely with the Conference Program Chairman (Len Ault, NASA HQ) and the Show Management (Joe Pramberger and Wendy Janiel, *NASA Tech Briefs*/Technology Utilization Foundation). Finalized all efforts regarding the presentation of papers. Initiated and completed the solicitation, selection and schedule of assignments of technical session moderators. Supervised a staff of about a dozen conference volunteers from NASA HQ, Goddard Space Flight Center and the Mid-Atlantic Technology Applications Center. Developed and completed the conference proceedings.

## 6.0 ADD-ON TASK STATUS

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### Other Conferences

- Coordinated efforts for Code C hand-out materials for the National Technology Initiative conferences at Palo Alto, CA, and Pittsburgh, PA, and the Software Valley Conference in Harpers Ferry, WV.
- Assisted in the initial coordination of efforts of hand-out materials and the use of STARS for the NASA Town Meetings.
- Developed and provided artwork to be included in the proceedings of the upcoming AFCEA Computing Conference and Exposition.
- Manned the NASA Technology Transfer Exhibit booth at ACCE, the 4th AFCEA Computing Conference & Exposition, February 2-4 in Washington, DC; at the Commercial Space Expo, April 13-14 in Colorado Springs, CO (held in conjunction with the 9th Annual Space Symposium); at IndustryTech '93, May 5-7 in Kansas City, MO; at the Technology Exposition: Yesterday, Today and Tomorrow, May 26-27 in Wallingford, CT; at TechNet '93 (AFCEA's National Conference), June 8-10 in Washington, DC; and at the Congressional Black Caucus, September 14-18, 1993 in Washington, DC..

### Technology 2003

- Developed all materials for and issued the Call for Papers for Technology 2003 to all FLC member contacts and NASA Field Center Directors; wrote copy for ads/articles that appeared in FLC's *Newslink* and *Commerce Business Daily*.
- Processed, categorized and reviewed all abstracts submitted in response to the Call for Papers for Technology 2003. Approximately 320 abstracts in all were received covering 15 technical categories.
- Worked with Len Ault from NASA and Joe Pramberger from Associated Business Publications to finalize the selection of papers to be presented, based on the ratings by the panels set up to judge each technical group of abstracts.
- Worked with Trade Show Manager Wendy Janiel (of the TU Foundation and ABP) to redeveloped all instructional materials, including any forms, regarding papers and presentations to be issued to all authors/speakers. Distributed these materials to all authors/speakers.

- Solicited and selected session moderators.
- Worked with Federal exhibitors in setting up technology demonstrations to be conducted at exhibit booths or in the press conference area as Industry/Media Briefings.



## 7.0 TRAVEL

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**October 2, 1992:** Dean Hering traveled to Washington D.C. to meet with The Robotic Industries Association Board, The National Food Processors Association and The National Soft Drink Association. Each organization represents a wide cross-section of industry. In each case, RTI has been invited to work with the technical subcommittees, composed of company representatives, to define problems facing the robotics, food, and beverage industries which might be solved by applying NASA technology.

**October 7-9, 1992:** Gary Hughes visited Kennedy Space Center for a CRADA workshop on electrically conductive polymers. J. Aliberti, B. Sheehan, K. Thompson of NASA, plus several from Los Alamos attended. Nine different candidate organizations were present, represented by a total of 13 individuals. All of the NASA prospects were there with the exception of the Steel Structures Painting Council which will be briefed separately.

**October 13-14, 1992:** Dan Winfield attended a meeting of the Society of American Gastrointestinal Endoscopic Surgeons to present the NASA Technology Transfer Program to their Corporate Council and Technology Committee.

**October 20-21, 1992:** Dan Winfield organized a meeting at the Florida Solar Energy Center (FSEC) to discuss a cooperative project between FSEC, NASA Kennedy, and Healthdyne Technologies, Inc. Mr. Winfield and Dr. Maria Kallergi, consultant to RTI, also evaluated a KSC-suggested computed tomography approach to digital mammography.

**October 20-21, 1992:** Doris Rouse traveled to Wheeling, WV to participate in meetings with staff at the National Technology Transfer Center.

**October 23, 1992:** Doris Rouse met with Frank Penaranda and Bob Cone at NASA HQ to discuss RTI Application Team activities.

**October 23, 1992:** S.A. Lehrman met with representatives of the U.S. Army Watervliet Arsenal and the Department of Energy at DoE Headquarters in Washington, DC. The purpose of the meeting was to discuss NASA's involvement in applying supercritical water oxidation to the destruction of Army generated hazardous materials.

**October 23, 1992:** S.A. Lehrman met with Mr. Stephen Moran, NASA Office of Aeronautics, Exploration and Technology, at NASA Headquarters to discuss opportunities to transfer NASA materials technology to U.S. industry.

**November 2-5, 1992:** Doris Rouse and Dan Winfield traveled to Scottsdale, AZ to participate

## 7.0 TRAVEL

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in the meeting of the Federal Laboratory Consortium. Dr. Rouse made a presentation entitled "Technology Commercialization: How to Make Products the Result of Your Projects." At the joint NASA/Dept. of Energy meeting, Dr. Rouse made a presentation on the assistance RTI provided in developing a joint project for development of conductive polymer coatings involving Kennedy Space Center and Los Alamos/DoE laboratory. This is the first joint project conducted under the NASA/DoE Memorandum of Understanding.

**November 4-6, 1992:** Dan Winfield and Dr. Maria Kallergi, RTI consultant, visited Jet Propulsion Laboratory to meet with four research and development groups concerning technology applications to digital mammography.

**November 10, 1992:** Doris Rouse and Steve Monteith traveled to Langley Research Center to meet with the TU Office staff and Frank Penaranda to discuss improved methods for tracking patents and new technology reports.

**November 18, 1992:** Doris Rouse made a presentation in Washington, DC on RTI's proactive technology transfer activities to the Organizational Process Action Team for the new Office of Advanced Concepts and Technology.

**November 19, 1992:** S..A. Lehrman participated in a meeting of the National Center for Manufacturing Sciences subcommittee on circuit board cleanliness held at Langley Research Center. Drs. Tom Yost and Chris Welch presented their work using optically stimulated electron emission as a tool for inspecting circuit boards.

**November 24, 1992:** Doris Rouse made a presentation on Application Engineering projects to the NASA Lewis Research Center Technology Transfer Task Force. Dr. Rouse also visited the Great Lakes RTTC, meeting with Chris Coburn to discuss collaborative activities.

**November 30-December 3, 1992:** The Team traveled to Baltimore to participate in Technology 2002. Activities included linking the Applications Engineering Program with other NASA and federal agency (e.g., Federal Highway Administration) programs, providing assistance to Field Centers (e.g. introducing technical staff to possible partners in industry and government), and providing information to industry about the NASA Technology Transfer Program.

**December 7, 1992:** Dan Winfield organized a meeting of the National Cancer Institute/NASA Work Group to begin review of responses to the Digital Mammography problem statement.

**December 9-10, 1992:** Gary Hughes attended a meeting at Kennedy Space Center, FL with Lockheed and the Electric Power Research Institute (EPRI). EPRI was interested in the scheduling software that is used to schedule the processing of the shuttle orbiters between



missions. The software was explained and demonstrated by Lockheed. Subsequent discussions were not fruitful because of financial constraints dictated by EPRI.

**January 13, 1993:** Dean Hering travelled to Florida to meet with the National Soft Drink Association Water Quality Committee to discuss waste water treatment technology needs. Representatives from Coke, Pepsi, Schwepps, and others enthusiastic about working together with NASA to meet the needs of the multi-billion dollar soft drink industry.

**January 14, 1993:** S.A. Lehrman participated in a Photonics Commercialization Workshop planning meeting at Goddard Space Flight Center.

**January 24, 1993:** S.A. Lehrman and Molly O'Donovan Dix participated in the Jet Propulsion Laboratory Adsorption Cooling Technology Commercialization Workshop in Chicago, IL. The workshop, co-sponsored by the Air Conditioning and Refrigeration Institute, attracted more than 45 attendees. Mr. Lehrman and Ms. Dix helped organize and conduct the workshop for the Jet Propulsion Laboratory Technology Affiliates Program Office.

**January 26, 1993:** Doris Rouse travelled to Washington, DC to participate in the National Technology Transfer Center program briefing.

**February 1-2, 1993:** S.A. Lehrman and Dean Hering met with Dr. Jim Rooney, Jack Jones, and Jim Schroeder of JPL to discuss follow-up plans for the Adsorption Cooling Commercialization Workshop. RTI gave JPL a videotape of the workshop. RTI also met with Jim Stephens of JPL to discuss the National Food Processing Association's need for an improved method for inspecting meat. Mr. Lehrman and Mr. Hering also toured the JPL Micro Devices Laboratory.

**February 1-3, 1993:** Gary Hughes travelled to Kennedy Space Center to assist with the Technology Briefing on the Ground Processing Scheduling System.

**February 12, 1993:** Dan Winfield organized and conducted a meeting at the National Eye Institute in Bethesda, MD between NEI and NASA Lewis researchers to discuss possible NEI testing of the Fiber Optic Probe for Early Cataract Detection.

**February 17, 1993:** S.A. Lehrman and Dean Hering participated in a meeting with Pepsi International, White Plains, NY, to discuss the NASA Technology Transfer Program. The meeting was a follow-up to Mr. Hering's presentation to the National Soft Drink Manufacturers Association.

## 7.0 TRAVEL

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**February 19, 1993:** Dean Hering travelled to Chicago to meet with the National Food Processors Association Packaging Technical Committee. He presented the NASA Technology Transfer Program to members (representatives from food packaging companies), progress to date on the first problem statement, and the process for developing new problem statements. While in Chicago, Mr. Hering met with the National Livestock and Meat Board which represents the entire meat industry. The Board works with users and manufacturers and funds projects to meet industry and consumer needs. Mr. Hering presented the NASA Technology Transfer Program to the Director of Research, who is very interested in working with NASA to address needs of the Board.

**March 1, 1993:** S.A. Lehrman attended a meeting at Goddard Space Flight Center to brief the presenters of the Photonics Commercialization Workshop. Mr. Lehrman emphasized to the presenters that they should use a presentation format that focused on the applications for their technology and answered commercial questions that industry could have.

**March 3-4, 1993:** Dan Winfield visited Johnson Space Center to review project status for on-going projects as well as to help assess new project opportunities.

**March 4, 1993:** Doris Rouse met with Jonathan Root at NASA HQ to assist in development of planning considerations for 2 year plan of the National Technology Transfer Center. Dr. Rouse also met with National Center for Manufacturing Sciences staff to discuss joint NASA/NCMS projects.

**March 23-24, 1993:** Doris Rouse and Molly O'Donovan Dix travelled to Marshall Space Flight Center. The main objectives of the visit were to attend a Technology Applications Board (TAB) meeting and to meet with Ismail Akbay and the Technology Utilization Office staff to discuss joint RTI/MSFC activities. While at MSFC Molly Dix was given a tour of the Productivity Enhancement Center. As a result of the visit RTI will assist MSFC with some of the inquiries fielded by the TAB process. RTI is also assessing MSFC technologies for potential technology-push candidates, and writing selected Spinoff sheets for Marshall success stories.

**March 24-25, 1993:** Dan Winfield visited Kennedy Space Center to discuss commercialization steps for the Bioluminescence Assay for Mycobacterium and the Medical Oxygen Concentrator.

**March 24-25, 1993:** S.A. Lehrman participated in the first Goddard Space Flight Center Photonics Commercialization Workshop in Greenbelt, MD. The workshop was attended by twenty-five companies interested in cooperative development and licensing of NASA photonics technology. Mr. Lehrman helped organize and conduct the workshop for the Goddard Technology Utilization Office.

**March 25-26, 1993:** Doris Rouse travelled to Johnson Space Center to meet with the new Technology Transfer Officer, Dick Ramsell, as well as Bill Milligan and Earle Crum in the New Initiatives Office at JSC.

**April 4-7, 1993:** Dan Winfield participated in the NASA Technology Transfer Network Conference in South Lake Tahoe, NV.

**April 19, 1993:** Gary Hughes met with the National Environmental Technology Applications Corporation (NETAC) in Pittsburgh. The objective of this meeting was to learn more about the technology transfer process and the environmental management industry.

**April 19-21, 1993:** Dan Winfield and Gary Hughes attended the Spring meeting of the Federal Laboratory Consortium in Pittsburgh, PA.

**April 20, 1993:** Gary Hughes met with the Air & Waste Management Association in Pittsburgh. This meeting was held to explore the possibilities of developing problem statements through this national organization.

**April 23, 1993:** Dan Winfield travelled to Washington, DC to (1) meet with NASA HQ on dual-use technologies and (2) meet with the National Cancer Institute and the National Electrical Manufacturers Association concerning the planned Digital Mammography Workshop.

**April 28, 1993:** Doris Rouse chaired a 30th Space Congress session entitled "30 Years Of Progress, Spinoffs From Space Technology" in Cocoa Beach, FL. Dr. Rouse also presented a paper entitled "Dividends from Space: How NASA Technology Has Provided A Competitive Advantage for Industry."

**April 28, 1993:** S.A. Lehrman participated in the American Society of Mechanical Engineers/National Laboratory Technology Transfer Committee meeting in Washington, DC. Mr. Lehrman arranged for NASA to write a technology transfer article for publication in the August, 1993 issue of ASME News.

**May 3, 1993:** Gary Hughes met with the leadership of the Center for Composite Materials, University of Delaware, Wilmington, DE. The Center for Composite Materials is serving as a source for a series of problem statements dealing with priority problems faced by the advanced materials industry.

## 7.0 TRAVEL

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**May 4, 1993:** Gary Hughes met with the Executive Director of the Hazardous Materials Control Research Institute, Greenbelt, MD. This organization will serve as a good connection to the hazardous waste treatment industrial community.

**May 5, 1993:** Gary Hughes organized several meetings with researchers and the Technology Utilization Office at the National Aeronautics and Space Administration Langley Research Center, Hampton, VA. The primary area of interest for this visit was nondestructive evaluation techniques for composite materials. A Center meeting which covered the status and future work on the carbon/carbon piston was also attended.

**May 18-20, 1993:** Dan Winfield travelled to Bethesda, MD to chair the NCI-NASA Workshop on Digital Mammography Technologies.

**May 19-21, 1993:** Doris Rouse travelled to Johnson Space Center, Houston, TX, to participate in the first meeting of the JSC Technology Commercialization Working Group including IC<sup>2</sup> and the Mid Continent RTTC.

**May 25-28, 1993:** Dan Winfield participated in a meeting of the NASA Operations Intercenter Work Group and gave a briefing on our technology transfer support. While at NASA Ames, Mr. Winfield also met with John Hines to prepare for meetings with companies interested in collaborating with NASA on medical measurement systems. While in California, Mr. Winfield also met with Stephen Gomes of Amtech to discuss areas for cooperation.

**June 1-2, 1993:** Doris Rouse made a presentation to the Primary Targeted to Secondary Targeted Technology Transfer Process Improvement Team in Washington, DC.

**June 10, 1993:** Gary Hughes attended a meeting with the Risk Reduction Engineering Laboratory of the United States Environmental Protection Agency, Cincinnati, OH. Representatives from Lewis Research Center presented information on an ion exchange material for removing heavy metals from industrial waste water.

**June 10, 1993:** Gary Hughes met with the University of Cincinnati Space Engineering Research Center. Several technologies, including an infrared technique for joining materials, appear to be candidates for commercialization.

**June 14-16, 1993:** Gary Hughes attended the Air & Waste Management Association Annual Meeting in Denver. He made contacts for future commercialization opportunities and for sources of environmentally related problem statements. Mr. Hughes also made a brief presentation to the hazardous waste committee.

**June 24, 1993:** Doris Rouse and Gary Hughes travelled to Langley Research Center to make a presentation to the Antenna and Microwave Research Branch with Joe Mathis and Frank Farmer of the Langley Technology Utilization Office. Technology transfer concepts were discussed to assist this branch with documenting past activity and to plan for more effective, proactive technology transfer processes in the future. The discussion led to an agreement that the RTI Team would assist AMRB in its technology transfer plans.

**June 28, 1993:** S.A. Lehrman and S. Mangum met with Mr. David Thompson, Chief, Economic and Commercial Crime Division, Victoria Police Department, Australia at Goddard Space Flight Center. The meeting was hosted by Don Vargo and attended by Ray Gilbert and Kevin Jackson. The purpose of the meeting was to discuss applications of NASA technology to combat computer crime.

**June 28-29, 1993:** Daniel Winfield and Molly O'Donovan Dix scheduled and attended meetings at NASA Ames with potential commercialization partners for the Ames Modular Sensor Conditioning System. Two separate meetings were held with two physiological monitoring companies to demonstrate and discuss the Ames' system. Both companies expressed interest in working with NASA.

**June 30, 1993:** Daniel Winfield and Molly O'Donovan Dix participated in a meeting at IVAC Corporation to discuss application of the Stennis predictive response algorithm to the IVAC electronic thermometer. The meeting resulted in the definition of a Phase I project to develop a proof-of-concept system.

**June 30, 1993:** S.A. Lehrman participated in the Lewis Research Center Process Improvement Team meeting on Secondary Technology Transfer. The meeting was held in Cleveland, OH and chaired by Bruce Banks. While at LeRC, Mr. Lehrman met with Tom Glasgow and Dr. Arnan Chait of the Computational Materials Lab to discuss their technology transfer activities.

**July 7, 1993:** Doris Rouse met with Frank Penaranda and Len Ault at NASA HQ to discuss RTI Application Team activities.

**July 13, 1993:** Stephen Lehrman met with John Sheridan and Dave Hicks of the National Center for Manufacturing Sciences in Ann Arbor, MI. The purpose of the meeting was to discuss the NCMS/Langley Research Center project on inspection of printed circuit boards using optically stimulated electron emission and the development of additional technology transfer projects between NASA and NCMS.

## 7.0 TRAVEL

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**July 13, 1993:** Stephen Lehrman met with Don Vincent, Executive Director of the Robotics Industry Association, in Ann Arbor, MI to discuss the development of industry-wide robotics problem statements.

**July 14, 1993:** Stephen Lehrman participated in a meeting at the Army Tank Automotive Research & Development Command in Warren, MI to discuss technology transfer between the federal laboratories and the automotive industry. Mr. Lehrman represented NASA. Bo Campbell (GM), Mike Epstein (USCAR), and D. Teague (Chrysler) represented the automotive industry. Harvey Drucker (Argonne), Gail Ehrlich (NIST), and Al Farkas (TARDEC) were among the federal lab representatives.

**July 14, 1993:** Stephen Lehrman met with Gregg Major of General Motors Electric Vehicle program in Detroit, MI to discuss the use of Lewis Research Center power management and distribution technology in the charging system for electric vehicles.

**July 23, 1993:** Molly O'Donovan Dix represented NASA at a USDA sponsored meeting with the Equipment Manufacturers Institute. The meeting resulted in the development of six problem statements generated by EMI member companies based on the RTI-developed problem statement format.

**July 27, 1993:** Dan Winfield traveled to NASA Headquarters for a meeting of the NASA-NCI Work Group and to discuss technology commercialization with Mel Montemerlo, NASA Program Manager for Operations/Artificial Intelligence.

**July 29, 1993:** Doris Rouse made a presentation on NASA Spinoffs in Rehabilitation to the Americans with Disabilities Act Expo '93 in Washington, DC.

**July 30, 1993:** Doris Rouse met with Bob Cone at NASA HQ to discuss RTI's work with industry associations.

**August 3, 1993:** Dan Winfield traveled to NASA Headquarters for technology transfer discussions with Dr. Joan Vernikos, Director, NASA Life Science, and Ray Gilbert, Code CU.

**August 5-6, 1993:** Doris Rouse, Carlene Cearley and Ron Lashaw travelled to Kennedy Space Center and the Navy Training Systems Center in Orlando, Florida to discuss software systems for technology transfer training.

**August 9-11, 1993:** Dan Winfield and Steve Lehrman traveled to JSC for meetings with various NASA technologists to seek out newly emerging technologies for possible cooperative technology transfer projects.

**August 31, 1993:** Stephen Lehrman and Ray Gilbert presented the RTI Technology Applications Team as a resource to the Office of Aeronautics (NASA Code R) for developing non-aeronautics technology transfer. Dr. Wes Harris, Dr. Len Harris, Dr. Kristin Hessenius, and Mr. John Facey represented Code R.

**September 1-2, 1993:** C. Gary Hughes and Stephen Lehrman visited Kennedy Space Center to review NASA developed technologies available for commercialization.

**September 15, 1993:** Dan Winfield traveled to Washington, DC for a meeting between NASA and the National Cancer Institute concerning a Joint Program Announcement.

**September 20-23, 1993:** Doris Rouse participated in a meeting at Ames Research Center to coordinate the technology transfer activities of the American Technology Initiative (AmTech), the ARC Technology Commercialization Center and RTI to best meet the requirements of ARC.

**September 27-28, 1993:** RTI hosted a meeting of the Regional Technology Transfer Center Directors and Code CU staff at the RTI Washington office. Doris Rouse represented RTI.

**September 28-30, 1993:** Gary Hughes travelled to Hampton, VA to attend the 5th and Final Combined Manufacturers' and Technologists' Airborne Wind Shear Review Meeting. A promotional brochure was developed and reviewed at this meeting. Future plans for technology transfer for the Antenna and Microwave Radar Research Branch were discussed.

**September 29, 1993:** Stephen Lehrman represented NASA at the American Society of Mechanical Engineers/National Laboratories Technology Transfer Committee (ASME/NLTTC) meeting in Washington, DC. The meeting focused on using the ASME/NLTTC as a means for identifying industry-wide problems, presenting these problems to federal scientists and engineers, and developing cooperative projects to apply federal laboratory technology to the solution of the problems.

**September 29-30, 1993:** Molly O'Donovan Dix travelled to Marshall Space Flight Center to meet with NASA researchers and from these meetings assess two technologies being considered for technology-push efforts. While at MSFC, Molly attended and participated in a Technology Applications Board meeting with the MSFC Technology Transfer Office.

**October 4-6, 1993:** Dan Winfield gave a presentation on Market-Driven Technology Transfer to the 47th National Conference on the Advancement of Research.

## 7.0 TRAVEL

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**October 7, 1993:** Stephen Lehrman and Ray Gilbert met with Kevin Ott, Executive Director of the Council for Superconductivity for American Competitiveness (CSAC). CSAC is the main industry group promoting superconductivity applications. They are interested in working with NASA on demonstrating superconducting electronics for satellite communications.

**October 8, 1993:** Stephen Lehrman participated in the American Society of Mechanical Engineers (ASME) Technology Opportunities Planning Committee meeting. Mr. Lehrman arranged for ASME to work with the NASA Technology Applications Team to develop an industry-wide problem statement concerning continuous monitoring of metals in atmospheric discharges from incinerators. Mr Lehrman also provided ASME points of contact within NASA for intelligent computer-aided training, expert systems development, knowledge acquisition tools, failure effects and analysis software, and real time data systems. These technologies are important to a new ASME project to develop a decision support system for the management of safety and availability of power boilers.



## **APPENDIX A**

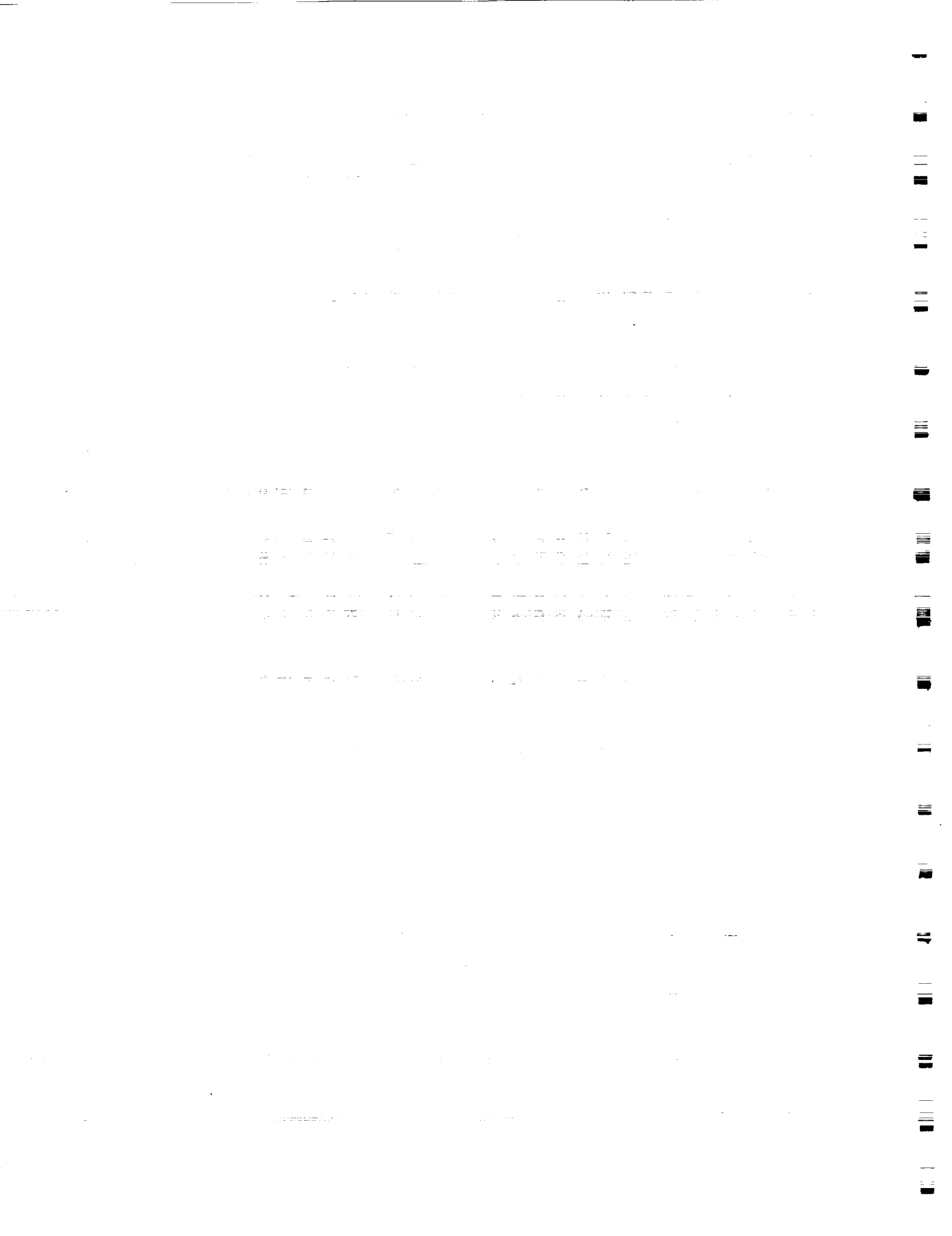
**NASA Technology Applications Team Staff**



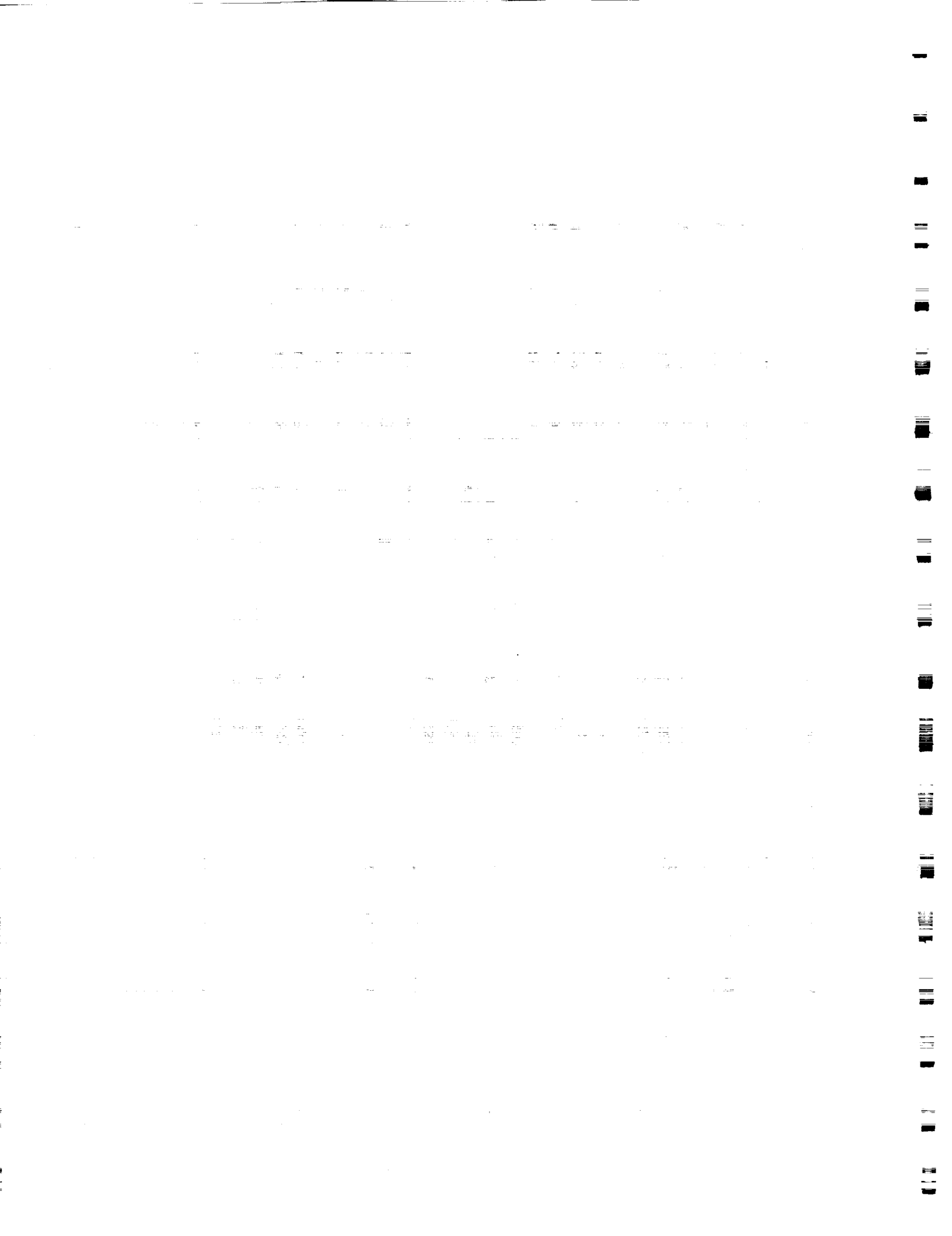
APPENDIX A: NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF		
STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
Doris J. Rouse, Ph.D.	<u>B.A., Chemistry/Ph.D. Physiology.</u> Sixteen years in NASA program. Five years research and management in industry.	Project Director: Assignment of project tasks to staff and consultants.  Program Planning, review for all Team projects.
Daniel L. Winfield, M.S.	<u>B.S., Engineering Analysis/M.S., Biomedical Engineering</u>  Nine years in NASA Technology Utilization Program. Eight years experience in product development and manufacturing in the medical device industry.	Coordination of biomedical and rehabilitation projects. Areas of specialization include ophthalmology and orthopedics.  Provides technical direction for Team activities.
Stephen A. Lehrman, M.S.	<u>B.S., Mechanical Engineering/M.S., Mechanical Engineering.</u>  Seven years in NASA Technology Utilization program. Thirteen years experience in mechanical design and analysis for manufacturing industries.	Coordination of manufacturing and industrial projects.  Areas of specialization include material science, mechanical engineering, precision engineering and optics.



APPENDIX A: NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF		
STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
Stephen D. Mangum, M.P.A.	<p><u>B.S., Political Science/M.P.A., Master of Public Administration.</u></p> <p>Serving sixth year in NASA Technology Utilization Program. Experience at NASA Headquarters' International Relations Division assessing the impact of the export of technology on U.S. industry and commercial competitiveness.</p>	<p>Serves as Program Analyst. Areas of concentration include organizational management, budgeting and finance, and database management.</p> <p>Assists project managers in background, marketing/industry studies and development of cofunding opportunities. Also, assists in the preparation of marketing and outreach materials.</p>
Dean H. Hering, M.S.	<p><u>B.S., Electrical Engineering/M.S. Electrical and Computer Engineering.</u></p> <p>Three years serving NASA Technology Utilization Program. Over six years experience in electrical engineering, digital design, neural networks, and Artificial Intelligence.</p>	<p>Coordination of manufacturing and industrial projects.</p> <p>Areas of specialization include electrical engineering, digital design, and Artificial Intelligence.</p>



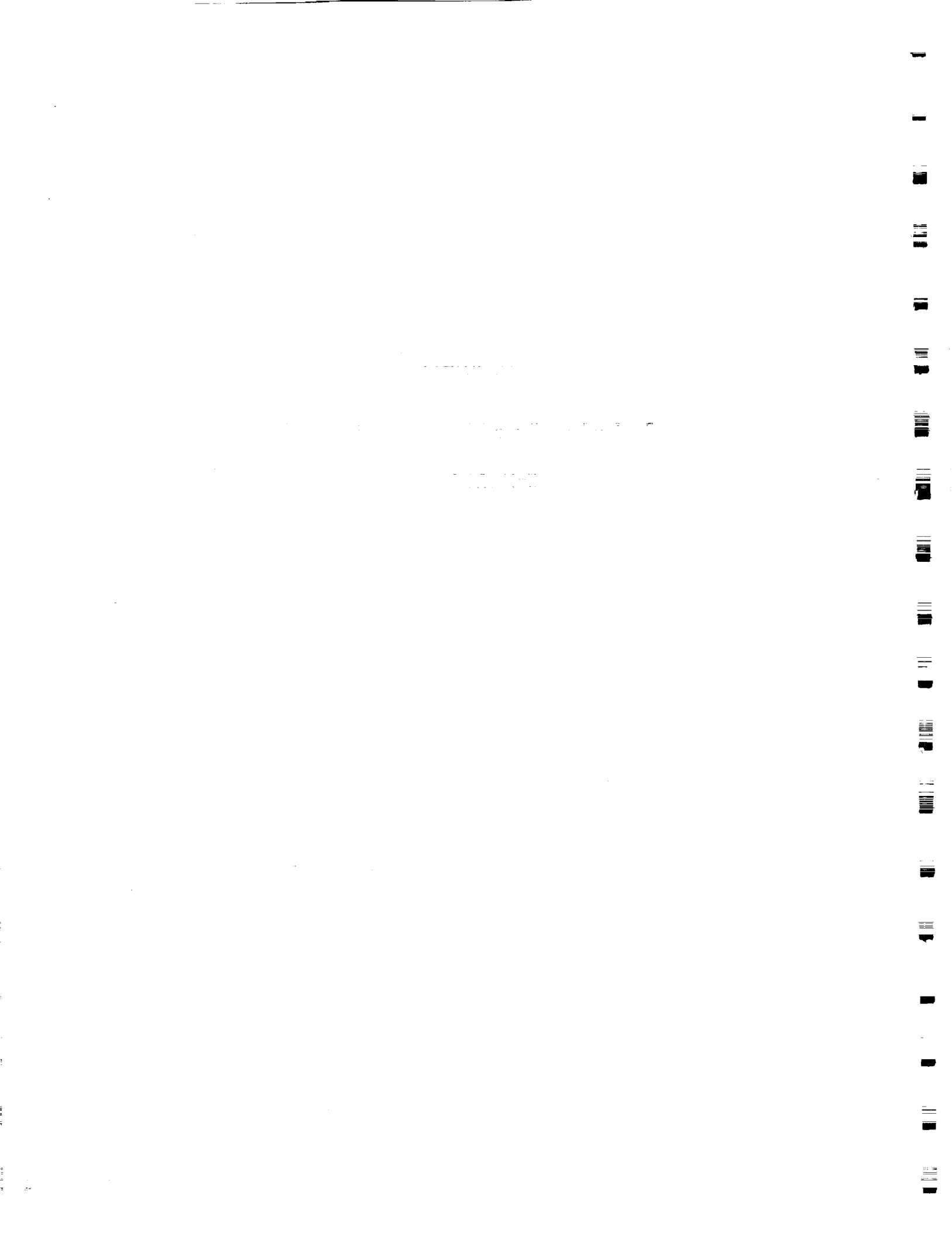
APPENDIX A: NASA TECHNOLOGY APPLICATIONS TEAM CORE STAFF		
STAFF MEMBER	BACKGROUND	PROJECT RESPONSIBILITY
C. Gary Hughes, P.E.	<p><u>B.S., Aeronautical and Astronautical Engineering / M.S., Aeronautical and Astronautical Engineering.</u></p> <p>Joined the NASA Technology Applications Team staff in 1992 after 25 years experience in industry.</p> <p>Broad experience base includes engineering and management in manufacturing, electric power plants, aerospace, consulting, market research and marketing.</p>	<p>Coordination of manufacturing and industrial projects.</p> <p>Areas of specialization include, mechanical and structural engineering, waste and environmental management, materials, and aeronautics.</p>
Molly O'Donovan Dix	<p><u>B.S., Mechanical Engineering</u></p> <p>Joined the Technology Applications Team in 1992 with three years experience in engineering services. Performed engineering assessments and recommendations for industrial and commercial electric energy conservation.</p>	<p>Coordination of industrial projects and provides research support to other Team staff. Provides technical writing for Technology Opportunity Announcement and Spinoff Sheets.</p>





## **APPENDIX B**

### **Technology Opportunity Announcements and Spinoff! Sheets**



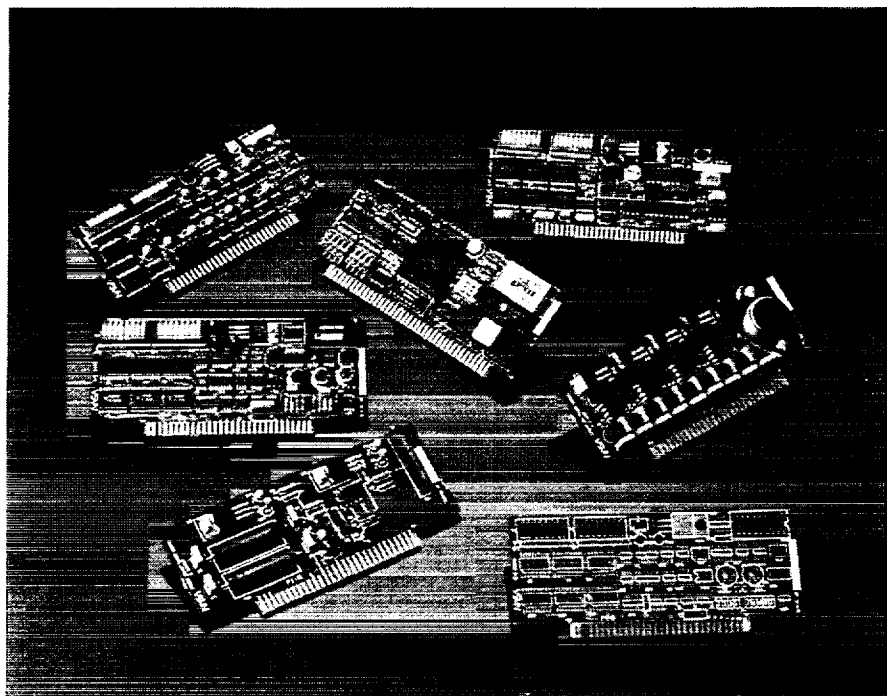


# NASA TECHNOLOGY TRANSFER

## *Commercial Applications of Aerospace Technology*

### A Modular Sensor Conditioning System

The National Aeronautics and Space Administration (NASA) seeks to transfer the completely developed sensor system described in this bulletin into commercial application. The system was originally designed for physiologic measurements during spaceflight missions; however, its modular construction makes it well-suited to a variety of sensor applications.



*Shown are the signal conditioning, control, memory, and power cards. These cards, contained in a compact enclosure, comprise the Modular Sensor Conditioning System.*

#### Product Profile

The Modular Sensor Conditioning System is a compact, programmable sensor-signal conditioning system that can be easily reconfigured by the user for different sensor-processing applications. The system consists of a 12-slot distributed-function backplane, seven signal conditioning cards, a three-card digital control and memory system, and two power supply cards for conditioning and isolating the output of the external power supply.

The signal conditioning cards may be configured to process different sensors. The modular design also allows new signal conditioning cards to be inserted for different ap-

plications. Each card filters the incoming signal into the appropriate bandwidth, scales the signal, and sends the data to the digital control and memory boards.

The digital control card uses a Motorola 68HC11 microcontroller and has onboard capability for A/D conversion, parallel digital interface to the signal conditioners, and RS-232 communications. Through the microcontroller, each signal can be programmed for gains, offsets, and sample rates, and calibration and operate modes are provided for each signal. The memory module provides 3.5 Megabytes of 8-bit data storage with a battery backup for portable applications.

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## Current System Configuration

BOARD	INPUT LEVEL (V)	GAIN RANGE	OFFSET RANGE (V)	FILTER RANGE (Hz)
EMG	.1 - 10 mV	400 to 40,000	2.5 nominal	2 to 1000
EEG	.01 - 10 mV	400 to 40,000	2.5 nominal	1 to 100
TEMP	0 - 1 V	0 to 100	2.5 nominal	Low Pass 1 Hz
ECG	1 V P-P	1, 2, 5, 10, 20, 50, 100	2.5 nominal	0.05 to 100
Dual RESP	1 V P-P	1, 2, 5, 10, 20, 50, 100	2.5 nominal	Low Pass 10 Hz
PWR Cond	± 8.5 V	N/A	N/A	N/A
PWR ISO	± 8.5 V	N/A	N/A	N/A
Micro-Controller	68HC11 Micro controller, provides parallel control ports to cards: 8 ch., 8 bit A/D converter, RS-232 Serial Communications Port			
Micro-Peripheral	Provides control for the memory plus battery backup for memory			
Memory	≥ 2 Mbytes 8 bit SRAM Memory			

The use of industry-standard parts ensures maximum flexibility in reconfiguring the system. The isolated power supply makes the system particularly suitable for biomedical use or for any application where safety and isolation is of prime importance.

### Features

- Modular construction using plug-in cards
- Compact: cards are 125 x 55 mm; entire system is only 220 x 150 x 70 mm
- Up to 16 channels of sensor data
- Each channel is user-programmable
- 3.5 megabytes of 8-bit memory
- Industry-standard parts
- Isolated power supply
- Onboard A/D converter

### Benefits

**Adaptable:** The system can be easily reconfigured by the user for specific applications. Modular construction and programmable data formats make the system particularly flexible.

**Rugged:** Extensive testing to qualify the unit for flight on the Shuttle ensures maximum reliability.

**Cost-effective:** The use of a fully-developed, ready-to-use, adaptable system, offers substantial savings in time and money over designing a system from scratch.

### Applications

NASA currently uses the system in Life Sciences Space-flight Programs for measuring physiologic signals. The table presents the existing system configuration.

The potential commercial uses of the technology include:

- Medical and biomedical sensing
- Process control
- Clinical research
- General instrumentation systems
- Factory processing
- Sensor fusion applications

### Technology Transfer Status

The Modular Sensor Conditioning System was developed by scientists at NASA's Ames Research Center. Transfer to the commercial sector is being coordinated by NASA's Technology Application Team at Research Triangle Institute as part of the NASA Technology Transfer Program. The program seeks to stimulate the use of NASA-developed technology in commercial applications.

### Contact

If your company is interested in the Modular Sensor Conditioning System, or if you require additional information, please contact the NASA Technology Applications Team:

Dean H. Hering, Research Engineer  
Research Triangle Institute  
P.O. Box 12194  
Research Triangle Park, NC 27709-2194

Phone: (919) 541-6924  
FAX: (919) 541-6221  
hering@conan.rti.org



# NASA TECHNOLOGY TRANSFER

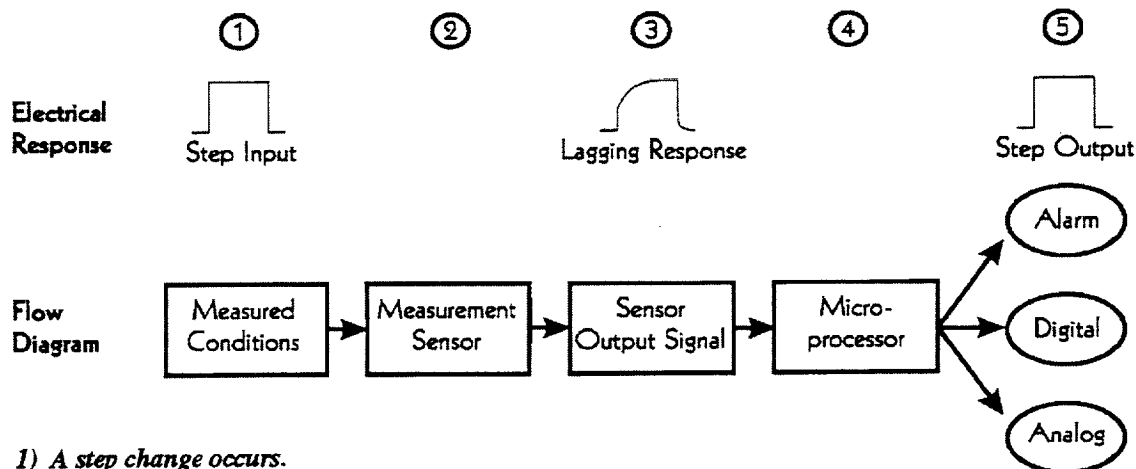
## Commercial Applications of Aerospace Technology

### Predictive Sensor Technology

#### Smart Electronic Thermometer

The National Aeronautics and Space Administration (NASA) seeks to transfer the signal analysis process, described in the following prospectus, into application as a method to increase the response speed of electronic thermometers. The method, developed at the John C. Stennis Space Center, is presently employed as a smart hydrogen detection system. The NASA system predicts the steady state response of a signal and thus can make a normally slow sensor faster. NASA seeks a company that is interested in utilizing this technology in industrial, medical, or veterinary applications.

#### SMART SENSOR



- 1) A step change occurs.
- 2) The measurement sensor reacts to the step change.
- 3) The output of the measurement sensor lags behind the actual conditions.
- 4) The analog output of the lagging sensor, sampled at regular intervals, is fed into a microprocessor employing a signal processing algorithm.
- 5) The microprocessor calculates and outputs the actual step change occurring during the sampled interval. The output signal is then relayed to an alarm, digital, or analog display device.

#### Product Profile

NASA researchers have developed a signal processing technique in an effort to overcome the shortcomings of commercially available hydrogen detection systems. The resulting system can be applied to increase the speed of response of any slow sensor which responds to a step input. The researchers that developed the technique have done preliminary feasibility studies demonstrating the technology's application to medical-type electronic thermometers.

The test system consisted of a commercially available, hospital-type electronic thermometer probe and custom analog circuit. The probe and circuit were integrated with the existing system's programmable microcontroller and a digital-to-analog converter. The microprocessor software was modified to run the predictive response algorithm and process the temperature data from the probe.

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## Benefits

The predictive response algorithm's greatest attribute is that it can enhance the speed of response of an existing sensor technology. A faster response can be attained without developing a faster sensor. Application of the predictive method could prove to be a cost-effective alternative for existing sensors that are limited by slow response times.

## The Technology

The system employs a signal-processing algorithm to determine, in near real time, the steady state response of a normally slow sensor. A microprocessor system samples the sensor's output at small, regular time intervals and dynamically predicts the sensor's response to a step change in temperature. Additionally, the algorithm, has been implemented in both C and BASIC programming languages and resides as firmware in Erasable Programmable Read Only Memory (EPROM).

## Technology Transfer Status

The transfer of the predictive sensing algorithm from the NASA/John C. Stennis Space Center to commercial production/use is being coordinated by Research Trian-

gle Institute (RTI) as part of the NASA Technology Transfer Program. RTI represents NASA as the Technology Applications Team. The Technology Utilization program seeks to stimulate the use of NASA-developed technology for nonaerospace commercial applications. The advantage of the system available for transfer is the increase in speed of response for existing sensing technologies.

## Contact

If your company is interested or you require additional information regarding either the predictive response algorithm or the technology transfer process, please contact:

NASA Technology Applications Team  
Molly O'Donovan Dix  
Research Triangle Institute  
P.O. Box 12194  
Research Triangle Park, NC 27709-2194

Phone: 919/541-5866  
FAX: 919/541/6221  
dix@conan.rti.org

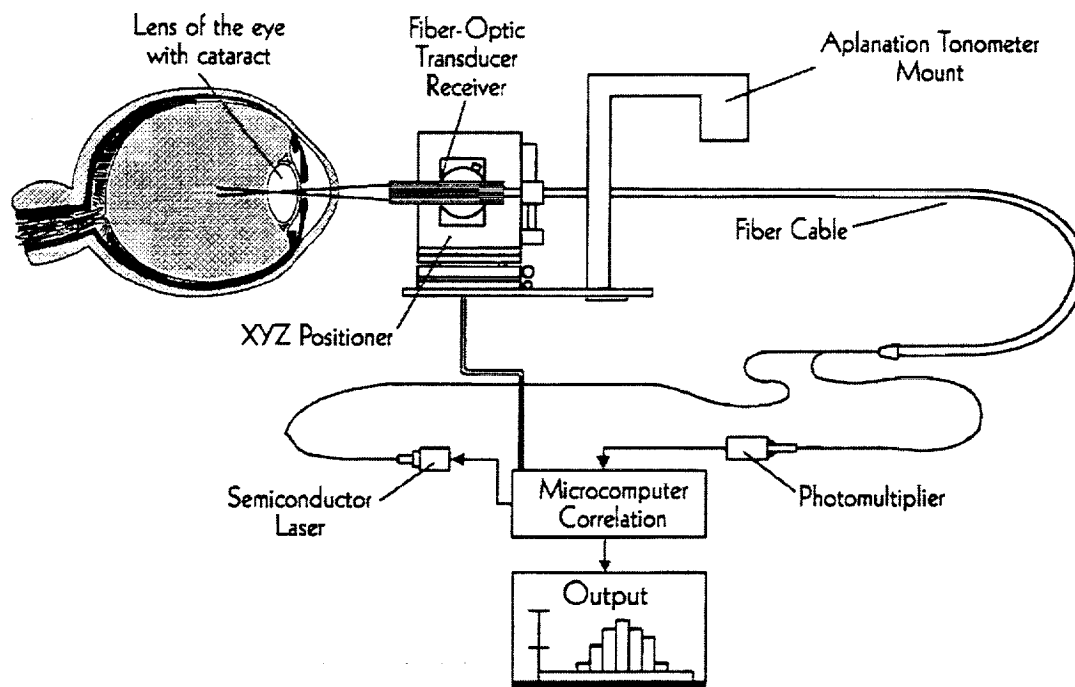


# NASA TECHNOLOGY TRANSFER

## *Commercial Applications of Aerospace Technology*

### Fiber Optic Cataract Probe

The National Aeronautics and Space Administration seeks a partner to develop a commercial version of a fiber optic probe for early detection of cataracts. The device was invented by NASA Lewis Research Center and State University of New York at Stonybrook as a rugged and compact sensor for space microgravity experiments. The noninvasive probe measures cataractous changes in human eye lenses by using dynamic light scattering, a technique that probes and characterizes the dynamic behavior of fluid systems. The fiber optic probe is compact, rugged, safe, sensitive, and easily mounted onto existing clinical devices.



#### Product Profile

Cataracts form when the normally transparent lens of the eye becomes cloudy. Changes to the proteins in the lens of the eye indicate the development of a cataract. The current clinical diagnostic technique, which involves visual inspection of the lens through a slit-lamp, lacks the sensitivity to detect the small cellular and biochemical changes of early cataract formation. The NASA fiber optic probe, with its increased sensitivity, could quantify even early lens changes and provide a useful tool for studies of cataractogenesis. Other possible ophthalmic applications of this probe include characterization of collagen fibrils in the corneal stroma and of protein molecules in the anterior chamber.

The sensitivity of the fiber optic probe was demonstrated in limited laboratory studies of bovine eyes and in human eyes from 18 to 73 year old donors. As a mammalian eye lens ages, alpha-crystallin, a protein specific to the lens, is converted to higher molecular weight. As these molecules aggregate, they give rise to a cataract. Bovine studies clearly show the increase in alpha particle size as a cataract develops. Studies on human eyes with the fiber optic probe show an increase in the average hydrodynamic diameter of alpha-crystallin from 20 nm in a normal eye lens to 80 nm in a cataractous lens. The technique easily reveals significant changes in alpha particle size in 43 and 55 year old

human lenses that clinically would have been judged to have only mild cataractous changes.

## The Technology

The fiber optic probe uses dynamic light scattering (DLS) to perform noninvasive measurements of lens protein size, size distributions and molecular weight. While DLS has existed for many years, its commercial use was limited by elaborate instrumentation, bulk optics, and alignment problems. This new probe overcomes earlier limitations by incorporating advances in solid state electro-optics and lasers, and fiber optic DLS spectrometers. The new system requires no lenses, has no moving parts, does not need alignment, and is insensitive to vibrations. At less than 5 mm diameter, the probe is designed to be rugged, compact, and effective.

The probe consists of two optical fibers contained in the same cable assembly. One fiber transmits a Gaussian laser beam from its source to the scattering medium, the lens of the eye. The second fiber is positioned at an established backscatter angle to collect and relay the signal to a photon detector. The laser light is tightly focused onto the lens. This focus provides high power density in the scattering volume, ensures good signal to noise ratio, and negates effects of scattering influences from the cornea and anterior chamber.

The fiber optic probe and positioner are mounted onto a universal aplanation tonometer mounting assembly. This arrangement allows for precise positioning and location of the scattering volume in any substantially transparent region of the anterior segment of the eye. The design also assures that the beam divergence beyond the lens will reduce the chance of radiation damage to the retina. Processing and analysis can be performed on a PC platform using a single digital correlator board, thereby limiting exposure time of the laser and automating data analysis.

## Safety

DLS measurements take between 30 seconds and 2 minutes per auto correlation. The damage threshold for retinal irradiance is  $2 \text{ W/cm}^2$  for a 10-second exposure. Expected retinal irradiance from this system is less than  $0.005 \text{ W/cm}^2$ , three orders of magnitude below the damage threshold. The application of the fiber optic probe is procedurally similar to techniques familiar to ophthalmologists such as aplanation tonometry and ultrasonography. The procedure can be performed eas-

ily at a slit lamp under the installation of topical (drop) anesthesia with minimal patient discomfort. Eye movement is negated by having the patient direct vision in the contralateral eye on a fixation light.

## Benefits

- Compact, less than 5 mm diameter
- Rugged, solid state electro-optics and lasers, no lenses, no moving parts
- Safe, minimal laser exposure & retinal irradiance
- Effective, high sensitivity, automated data analysis, easily mounted on standard ophthalmic equipment.

This new probe's primary value is its ability to detect and quantify early to moderate cataracts. Mechanisms initiating cataract formation are well understood, but the point at which cataractous formation becomes inevitable and irreversible remains to be identified. This technology could be used to evaluate the efficacy of cataract prevention and treatment research. Clinically, this procedure could monitor for very early cataractous side effects of chronic steroid therapy.

## Technology Transfer Status

This technology opportunity is part of the NASA Technology Transfer Program. The Program seeks to stimulate development of non-aerospace commercial applications from NASA-developed technology. The NASA Lewis Research Center seeks a commercial partner to develop a clinical prototype, conduct clinical testing, and ultimately commercialize the fiber optic probe discussed in this sheet. The National Eye Institute has expressed interest in conducting multi-center clinical trials using the fiber optic probe upon completion of the initial clinical studies performed with a commercial partner.

## Contact

If your company is interested in this fiber optic cataract probe, please contact:

Daniel Winfield  
NASA Technology Applications Team  
Research Triangle Institute  
P.O. Box 12194  
Research Triangle Park, NC 27709-2194  
(919) 541-6431  
(919) 541-6221 - Fax





# NASA TECHNOLOGY TRANSFER

## *Commercial Applications of Aerospace Technology*

### Ultrasonic Displacement Amplitude Measurements

The National Aeronautics and Space Administration (NASA) seeks to transfer into the commercial sector a technology for absolute measurement of ultrasound displacement amplitude. The technology, developed at NASA's Langley Research Center (LaRC), offers the opportunity to accurately measure the displacement amplitude of an ultrasonic plane wave with a sensitivity of less than one angstrom. The technology is based on the LaRC patented electrostatic acoustic transducer (ESAT). The precision offered by this technology will allow accurate, controlled studies of the bioeffects of ultrasound and may serve as a quality assurance tool for ultrasound manufacturers. In addition, the technology may be applied to the study of ultrasonic properties of liquids, including liquid-state anharmonicity, ultrasonic dosimetry for biological applications, lithotripsy research and ultrasonic spectral analysis.

#### Electrostatic Acoustic Transducer

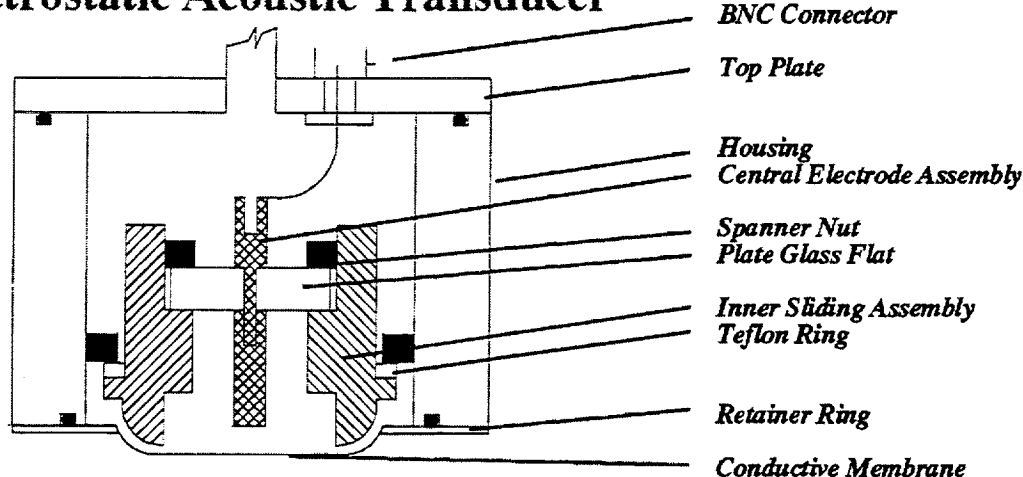


FIGURE 1

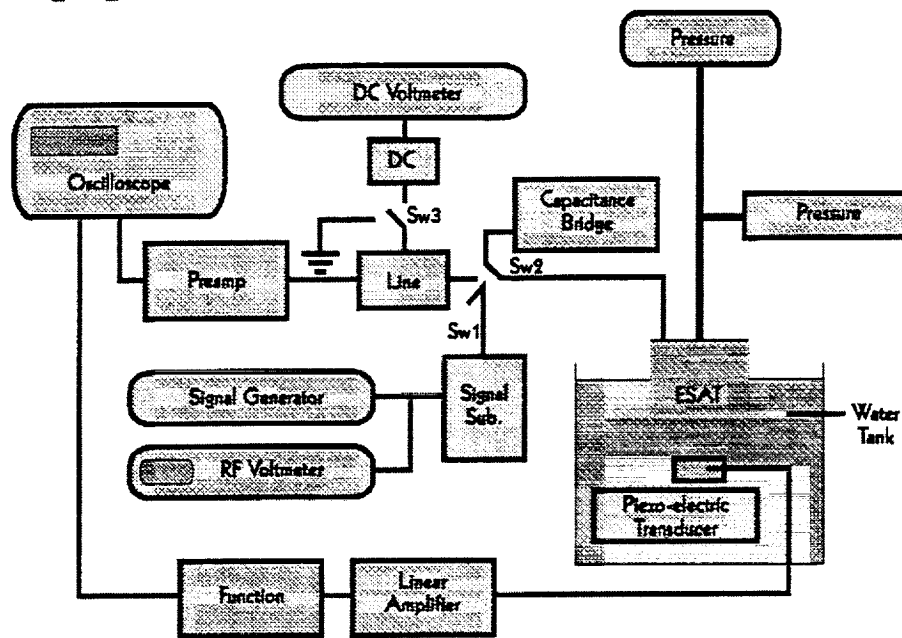
#### Market Need

There is documented need for a national reference standard for measurement of ultrasonic exposure levels produced by medical ultrasound devices. Organizations such as the World Health Organization, the National Council on Radiation Protection and Measurements, and the National Institute of Health have all noted the lack of information regarding safety and exposure to medical diagnostic ultrasound. The Research Agenda for the 1990s, produced by the Food and Drug Administration (FDA), specifically asked for a calibration standard to be readily available for use by manufacturers, bioeffects researchers, clinicians and federal agencies. The technology from NASA-Langley has the accuracy to be applied as a primary standard for ultrasonic displacement amplitude measurements.

#### NASA Technology

NASA's technology is capable of absolute measurement of ultrasonic compressional wave particle displacement amplitudes through the use of a patented electrostatic acoustic transducer (ESAT), Patent No. 4,080,960. The ESAT is illustrated in Figure 1, and the set-up that utilizes the ESAT is shown in Figure 2. The ESAT has a conductive membrane stretched over a recessed electrode that acts as a conductive surface and mimics the liquid-membrane interface. The membrane responds to the compressional wave impinging on its surface, and the displacement of the membrane generates an electronic signal with a voltage dependant on the magnitude of the displacement, the DC bias voltage and the frequency of the wave. Accuracy of the technique is within 2.3 to 4 percent in the frequency range of 0.5 MHz to 15 MHz.

## Equipment & Assembly



*The ESAT sits in a tank of water. A pneumatic circuit maintains a constant electrode gap spacing during measurements. Electrical tone bursts are generated and impinge upon the ESAT. The amplified ESAT output is displayed on an oscilloscope. During absolute measurement, the ESAT is disconnected and the signal frequency generator is set to match the tone burst frequency. The generator amplitude is adjusted to match the height of the previously measured ESAT output. The RF voltmeter measures the level of the signal.*

Figure 2

### Benefits

Limitations of the existing measurement methods – hydrophones and the radiation force balance method – can be overcome by the NASA technology. PVDF hydrophone users can benefit from the Langley technology by gaining the ability to easily and accurately re-calibrate periodically during a given process. The technology developed at Langley provides a significant increase in accuracy resulting from the ability to correct for diffraction errors. In addition to significant error reduction, several other advantages to the Langley technology include easy set-up, reusability, and readily available equipment.

### Applications

Applications include the study of ultrasonic properties of liquids, including liquid-state anharmonicity, ultrasonic dosimetry for biological applications, lithotripsy research, and ultrasonic spectral analysis. The system may be best suited as a primary standard because the diameter of the receiver and transducer must be equal to correct for diffraction errors.

### Technology Transfer Status

NASA is seeking commercial applications that may require the characteristics of the new technology and a commercial partner to develop the technology. Transfer of the technology is being coordinated by NASA's Technology Applications Team at Research Triangle Institute as part of the NASA Technology Transfer Program. This program seeks to stimulate the use of NASA-developed technology in commercial applications.

### Contact

If your company is interested in the Electrostatic Acoustic Transducer (ESAT) and its application as a system for measuring absolute acoustic particle displacement, or if you require additional information please contact the NASA Technology Applications Team:

Molly O'Donovan Dix  
Research Triangle Institute  
P.O. Box 12194  
Research Triangle Park, NC 27709-2194  
919/541-5866



# NASA TECHNOLOGY TRANSFER

## *Commercial Applications of Aerospace Technology*

### Virtual Reality Data Visualization Technology

The National Aeronautics and Space Administration (NASA) seeks to transfer into the commercial sector technology to visualize data with virtual reality (VR) capabilities. NASA and its partners offer for transfer computer software that can crop and clean digital images, describe a surface of a volume as polygons using a series of sequential digital images, then finally translate these surfaces as three-dimensional (3-D) stereo images. This technology has been used to create a series of programmed "fly throughs," allowing the observer to experience virtual reality during a tour through the human skull and heart. These "fly throughs" are also available for transfer to the commercial sector. The current research emphasizes creating a high resolution virtual reality simulator of a human body for educational purposes, but many other potential applications for this technology exist where complex 3-D structures are studied.

Studying 3-D images on a two-dimensional (2-D) computer screen can be compared to looking at fish through a glass-bottomed boat, whereas VR allows one to put on the scuba equipment and interact with the surroundings without getting wet. VR interface is intuitive and utilizes spatial and psychomotor abilities that are now constrained or reduced by the current 2-D terminals and keyboards.

Endowing medical students with an understanding of the human body poses some difficult challenges. One of the most difficult is to convey the 3-D nature of anatomical structures. Recently there has been a tremendous increase in interest in creating computer based human anatomic studies, including commercially available interactive educational software. No available software programs yet offer VR as a tool to study human anatomy. VR not only offers invaluable educational advantages in the study of human anatomy, but also in any other area where complex three-dimensional relationships need to be studied.

#### NASA Technology

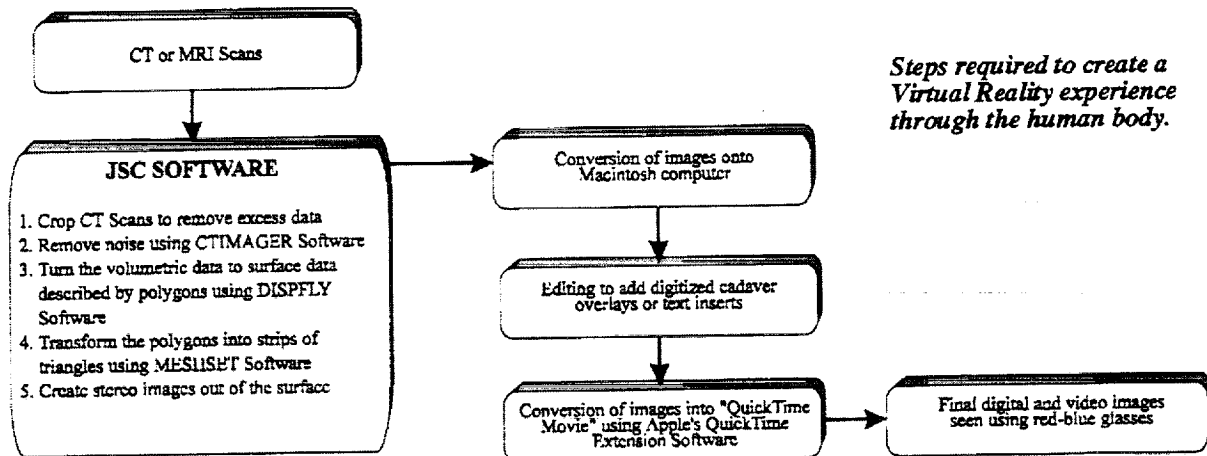
NASA began work with VR to assist with astronaut training using models of the shuttle and space station at NASA's Johnson Space Center (JSC). Since the development of this model, NASA and its partners Lin-Com Corporation, the University of Texas Medical Branch at Galveston, and the Galveston Independent School District have teamed up to develop Virtual Visual Environment Display (VIVED) that provides a unique educational experience using VR technologies.



Astronaut in Orbit

*Virtual Reality technology provides a unique educational experience allowing the observer to travel through complex three dimensional objects.*

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A schematic describing the steps involved in creating a VR experience through the human body is presented on the back of this sheet. CT/MRI slices, which are 1.5 mm thick, are being used to create images of astounding resolution. The JSC software, when run on the Silicon Graphics computer, makes it possible to turn these slices into 3-D volumetric images and movies of the observer "flying through" the body in a prescribed pattern.

### The Product

The Macintosh computer was selected for viewing the final 3-D images because it is relatively affordable and is in widespread use in school systems. The end product of the virtual reality movie can be stored either on a hard drive or transferred onto video tape and viewed through red-blue glasses. Many other forms of multimedia can be incorporated into the finished product. A VR head-mounted display (HMD) or boom system can be used to view the final images. CD ROM or laser disc can also be used to store the final images. The computer can allow for interaction so that the user can "freeze" an image and query about what is seen. Audio can easily be added to allow for narration or music during sequence viewing.

Current limitations in data processing rates due to the high resolution of the body images prohibit the observer from "flying" through the human body at will; instead only the technology to create prescribed "fly-throughs" is currently available. Alternative hardware and software options are being explored to deal with this problem. With less data-intensive applications, i.e., with applications requiring less resolution, the technology is available for a full interactive virtual reality experience.

### Applications

Applications for this technology include any area in which complex three-dimensional relationships must be understood, such as:

- Anatomy education
- Education for mechanics of all types
- Education for chemistry students
- Pathology studies for surgeons
- Simulation of plastic and reconstructive surgery
- Endoscopic training for surgeons

### Technology Transfer Status

NASA seeks commercial applications that may require this new technology and a commercial partner to develop the technology for these applications. Transfer of the technology is being coordinated by NASA's Technology Applications Team at Research Triangle Institute as part of the NASA Technology Transfer Program. This program seeks to stimulate the use of NASA-developed technology in commercial applications.

### Contact

If your company is interested in this Virtual Reality Data Visualization Technology and its application for preprogrammed virtual reality experience through the human skull and heart, please contact the NASA Technology Applications Team:

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P.O. Box 12194  
Research Triangle Park, NC 27709-2194  
(919) 541-7202  
(919) 541-6221 - FAX



# NASA TECHNOLOGY TRANSFER

## *Commercial Applications of Aerospace Technology*

### Wireless Infrared Communications

#### *Short Range Digital Communications Without Cables*

Technological advances in communications equipment, such as pagers and cellular phones, are rapidly increasing the mobility of the American worker. The recent addition of radio-based communications to portable computers is further expanding the numbers of mobile computing Americans. Some problems, however, are associated with very short range transmissions of radio frequency signals in work environments. NASA engineers and the Wilton Division of K&M Electronics, Inc. have cooperatively addressed the problems of interference in radio frequency transmission of voice and data in small, enclosed spaces. The NASA-Wilton team developed a set of flexible wireless infrared (IR) communication systems. Commercial derivatives of the NASA wireless IR systems are now used by a diverse group of industries.



*Astronaut "Pinky" Nelson tests a NASA-developed wireless communications system for use on the Shuttle*



*AT&T uses the technology in switching stations to simplify field communications*

#### **The Product**

Wilton's IRplex 1000 Wireless RS232 Cable Eliminator provides a local area network (LAN) capability without the need for cabling. Computers, printers, plotters, and other electronic equipment having serial ports within an office or laboratory can be connected without the traditional tangle of cables. Costs associated with computer equipment moves and cable routing and rerouting

are eliminated by the Wilton system since its design provides for multi-room and large area coverage. IRplex 1000 port hardware forms a wireless RS232 compatible network which transmits messages bidirectionally in full-duplex by means of indirect infrared light propagating in open air. By using infrared light, IRplex 1000 is freed of many of the problems of radio frequency (RF) commu-

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nications systems. Because of its reliability, Wilton IRplex equipment is currently in use in automobile factories and electric utility substations providing wireless RS232 communication between equipment. Office environments benefit from the IRplex cablefree connections for printer sharing, PC-to-PC communication, laptop computer links, etc.

### **NASA's Involvement**

During early development of NASA's large manned spacecraft programs, such as Space Lab and the Space Shuttle, an area of concern was entangling astronauts in the floating cables of their communications equipment. This same problem arose as wires associated with data collection from devices attached to astronauts' bodies for life sciences experiments became longer and more numerous. To address the problem of weightless and fixed-length cables, NASA engineers at Johnson Space Center prototyped systems for wireless infrared transmission of astronaut voice communications and physiological data using Wilton's IR technology.

Following promising early results, NASA initiated several contracts with the Wilton Division of K&M Electronics, Inc. of Ridgefield, Connecticut, to engineer and fabricate several hardware systems including equipment for a Shuttle flight experiment. These wireless infrared communications systems have since been used extensively at NASA Johnson for a range of single and multichannel voice and digital data transmission applications, including a 16 channel wireless voice IR system that supports eight simultaneous astronaut conversations.

Funds for the NASA/Wilton wireless IR development work were provided in part by NASA's Technology Utilization Office and by the NASA Small Business Innovative Research (SBIR) Program. The NASA Technology Applications Team assisted in project development.

### **Technology Benefits**

**Wireless:** The IRplex 1000 and higher speed IRplex 6000 eliminate cables for computer communication links in factory, laboratory, office and other computer-occupied spaces.

**Interference Free:** By using infrared light, the IRplex products are free of the health hazards and interference problems of radio frequency (RF) communications.

**Flexible:** The high speed and modular design of the IRplex technology allows it to support multiple standard communications protocols and various combinations of digital voice and data transmissions.

### **Other Applications**

The IRplex system technology supports the transmission of digital voice and data equally well. This dual capability is leading to a growing list of other applications for the technology. One application is real-time wireless tracking and location of equipment and staff in hospital and other healthcare facilities. A second new system application, which is now supplied to AT&T by Wilton, is a wireless IR telephone system tailored to the voice communication needs of the wiring rooms of telephone central offices. This application of the IRplex technology enables several central office wiring technicians to maintain non-interfering, cableless telephone links with field technicians. Thus, this system optimizes the installation and maintenance of hundreds of telephone lines each week.

### **Contact**

For more information on this product or technology, please contact the Johnson Space Center, Technology Utilization Office:

Johnson Space Center  
Technology Utilization Officer  
Mail Code IC4  
Houston, TX 77058  
Attn: Dean C. Glenn  
Phone: (713) 483-3809

or:

Wilton Division  
K&M Electronics, Inc.  
P.O. Box 504  
Ridgefield, Connecticut 06788  
Attn: James W. Crimmins  
Phone: (203) 438-0316



# NASA TECHNOLOGY TRANSFER

*Commercial Applications of Aerospace Technology*

## Capaciflector

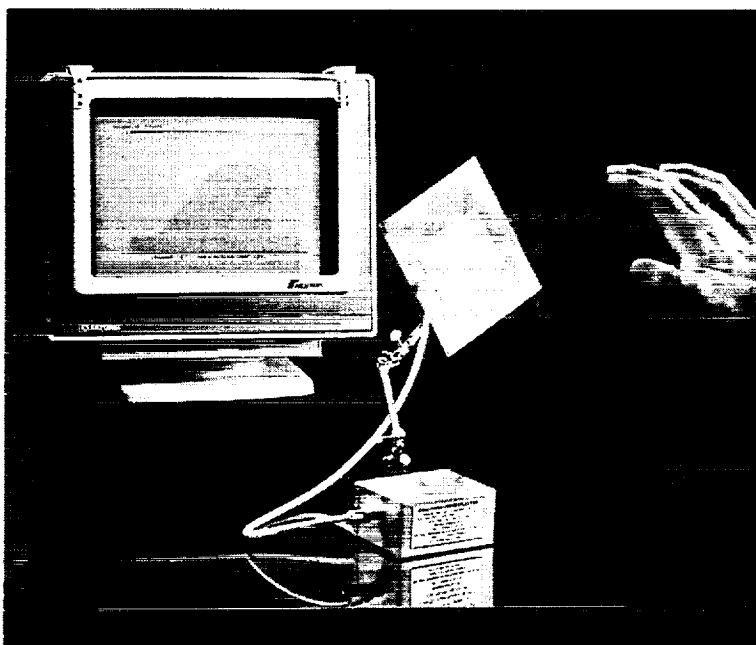
*Capacitive Reflector for Proximity Sensing*

The role of robotics continues to develop as robots become integral elements of many manufacturing environments and functions. However, the potential for collision when integrating robots into manufacturing areas or alongside humans creates a significant safety problem. To ensure the safety of astronauts working with robots in space, NASA developed the Capaciflector, a proximity-sensing skin that attaches to the robotic manipulator. The Capaciflector can accurately detect objects and thus enables robots to avoid collisions. The Capaciflector technology, which can be applied to numerous proximity-sensing applications, is now commercially available from Computer Application Systems, Inc. (CASI) as a result of a licensing agreement with NASA. This Spinoff sheet describes NASA's Capaciflector technology and is presented as an example of a successful transfer of NASA technology to commercial application. If you are interested in the Capaciflector technology or the NASA Technology Transfer program, please contact the appropriate individual identified on the back of this page.

### The Technology

In exploring the possible use of a capacitive array for collision avoidance, NASA found that the sensor range of existing systems was typically one inch, not sensitive enough to detect and react to an object. To increase the range and sensitivity of existing capacitive sensors, researchers at NASA's Goddard Space Flight Center developed the Capaciflector, a capacitive-sensing element backed by an active reflector. The reflector element acts as a shield to reflect field lines away from the grounded manipulator to which the sensor is attached.

The Capaciflector is able to dramatically increase the range and sensitivity of the capacitive sensor by shielding the sensor from the underlying ground of the manipulator and directing the electric field toward the object being sensed. This configuration reduces the standoff required



by the sensor, enabling the sensor to be incidental to the robot arm. The Capaciflector, when integrated with a robot controller, provides enough sensitivity for robotic path planning and control for most applications that include human interaction.

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## CAPACITIVE SENSOR PRINCIPLES

Figure 1

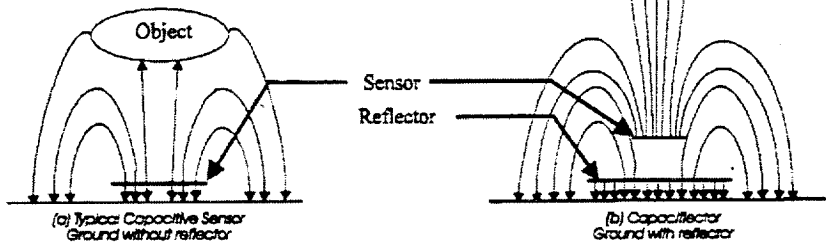


Figure 1(a) shows a typical capacitive sensor with a reduced range resulting from coupling with the manipulator (ground). With the Capaciflector, Figure 1(b), the field lines from the sensor are prevented from returning directly to ground. This shielding reduces the capacitive coupling between the sensor and manipulator and increases the effective sensor range.

### Other Applications

The Capaciflector technology lends itself to:

- > process control;
- > proximity sensing and object avoidance;
- > capacity (volume) monitoring;
- > vibration monitoring and counting;
- > object monitoring, including speed, size, and shape determination; and
- > security and safety.

### The Product

Capaciflector technology is now commercially available from Computer Application Systems, Inc. (CASI) as a result of a licensing agreement with NASA. CASI manufactures and sells the sensors for a diverse group of applications, including path definition and obstacle detection for a robotic tower climber and process control for manufacturing. The sensor can be built to various size, shape, range, and sensitivity specifications.

### Technology Benefits

The Capaciflector offers these improvements:

- > Increased sensitivity and range;
- > Rugged, compact, noninvasive, and robust;
- > Omni-directional (no receiver required);
- > Flexible configuration (diverse applications);
- > Reduced sensor standoff that reduces the bulk of the sensor, and eliminates parameter reprogramming;
- > Economical - reduced costs resulting from reduced hardware, reduced mounting area, and reduced manipulator adaptation.

### NASA's Involvement

The Capaciflector was developed by NASA to help robots "see" and avoid objects. The original prototype sensor was built and tested at NASA's Goddard Space Flight Center. NASA transferred the technology from Goddard to CASI under its Technology Transfer Program. This transfer was assisted by NASA's Technology Applications Team at Research Triangle Institute (RTI). RTI developed a detailed and comprehensive information package that enabled targeted companies to evaluate the Capaciflector technology based on technical and market descriptions. As a result of RTI's assistance, CASI obtained a nonexclusive license for the Capaciflector technology from NASA.

### Contact

For more information on this product or technology, please contact Goddard Space Flight Center's Technology Utilization Office at:

Goddard Space Flight Center  
Mail Code 702

Greenbelt, MD 20771

Attn: Nona Minnifield

301/286-8504

or:

Computer Applications Systems, Inc.

P.O. Box 251

Signal Mountain, TN 37377

Attn: Craig Harston

615/752-1787





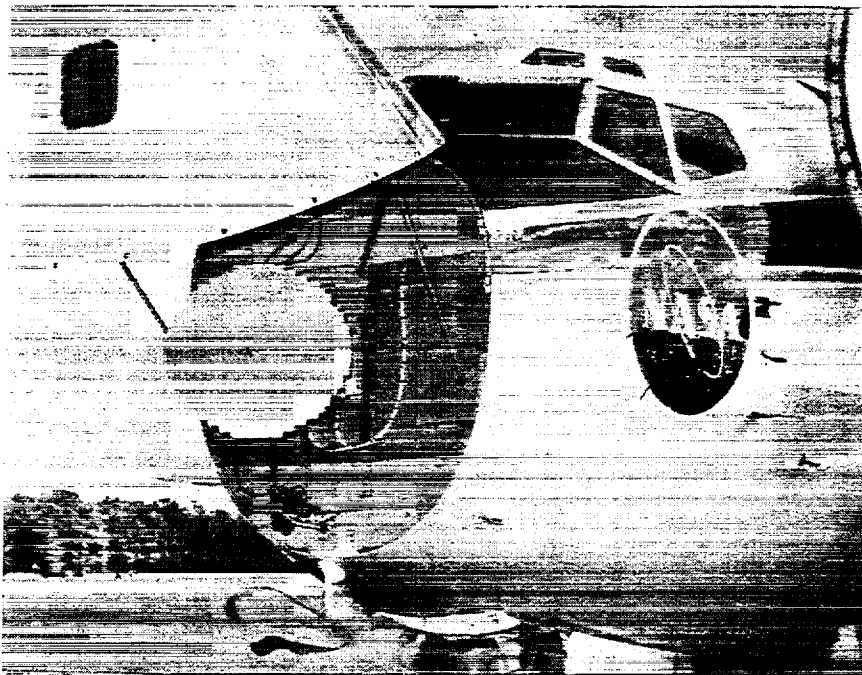
# NASA TECHNOLOGY TRANSFER

## *Commercial Applications of Aeronautics Technology*

## Wind Shear Sensing Systems

### *Lifesaving Early Warning*

A meteorological phenomenon known as a "microburst" can occur in or near thunderstorms and is often responsible for a particularly nasty form of wind shear. This wind shear can cause large and small aircraft alike to lose control and crash with little or no warning. Between 1964 and 1985, there were over 26 U.S. airline accidents, 626 fatalities, and 200 injuries caused by wind shear. In addition to new training and weather-avoidance procedures, the Federal Aviation Administration (FAA) in 1988 mandated that airlines install wind shear warning devices, or detection and avoidance systems, by the end of 1993. NASA scientists at Langley Research Center have worked with several avionics and airline industry representatives to develop predictive systems for wind shear avoidance systems.



*A wind shear sensing system using microwave radar is installed in the nose of this 737. This system sends a microwave radar signal ahead of the aircraft to seek raindrops and other moisture particles. The returning signal represents the motion of those particles, which is then translated into wind speed.*

### The Technology

The FAA requirement mandated the installation of reactive systems for wind shear detection. However, four airlines, American, Continental, Eastern and Northwest, obtained extensions until 1995 in satisfying this requirement because of their cooperative efforts in developing predictive systems with NASA. Reactive systems are not capable of giving advance notice of wind shear. They alert the flight crew

after wind shear is encountered. Following this warning, the crew can then take corrective action to avoid contact with the ground. Predictive systems, however, are designed to provide 10 to 60 seconds of warning when wind shear conditions exist in the flight path. This amount of time is adequate for the flight crew to maneuver around or safely through a hazardous wind shear condition.

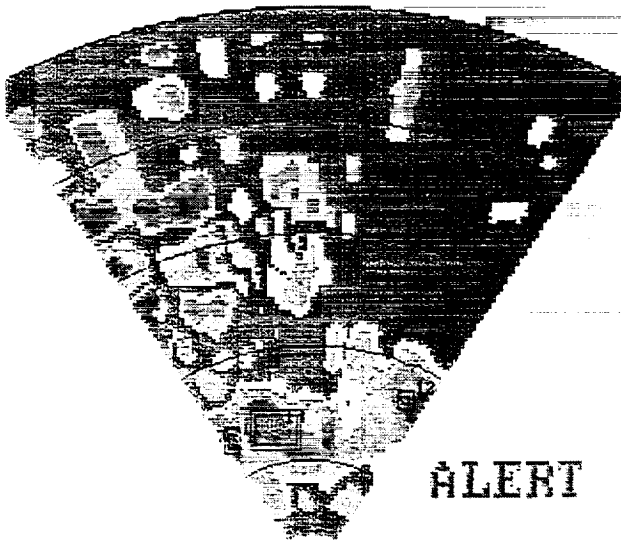
Three different types of sensor technologies were investigated for predictive systems:

- > microwave doppler radar,
- > Doppler light detecting and ranging (LIDAR) radar (uses laser light); and
- > infrared sensors

### NASA's Involvement

In 1985 NASA (Langley Research Center) and the FAA began a wind shear study program. In 1988, after the FAA rule was issued, the four airlines and a number of avionics companies joined the action. In 1991, NASA flight-tested prototypes of microwave-based and infrared type systems for detecting microburst wind shear in the flight path of the Boeing 737 test aircraft. A laser-based system, LIDAR prototype was added to the test program in 1992.

The NASA team, which included scientists from Research Triangle Institute, also developed a comprehensive set of wind shear data from its numerous test flights. This information was used to develop analysis software, hazard definition criteria, and certification criteria. This dataset can be used for development and certification of all types of wind shear detection system designs. In addition, the NASA team developed wind shear simulation software to enable design work to proceed without having to actually fly the equipment into wind shear conditions.



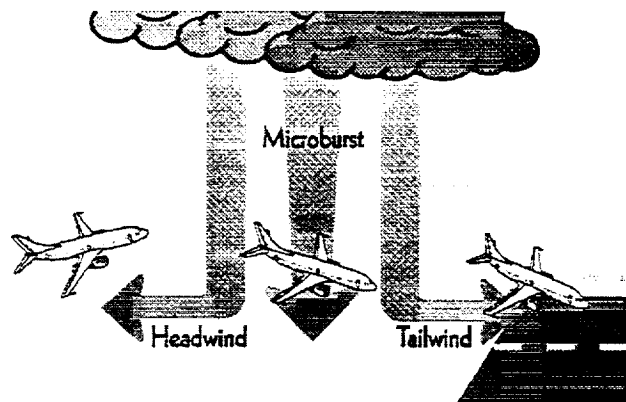
*The radar screen, above, shows a recent storm and alerts the pilot that microburst conditions exist.*

### Products

Several avionics firms, including AlliedSignal Air Transport Avionics, Rockwell International, Collins Air Transport Division, and Westinghouse developed their versions of airborne microwave Doppler wind shear detection sys-

tems. Each company was supplied with the analysis software, simulation software, and baseline data developed by NASA to adapt their existing radar designs to the specific problem. These companies and three airlines (Eastern dropped out) have recently performed flight tests of their wind shear detection systems. They are also working towards FAA certification in the near future.

Turbulence Prediction Systems continues its effort to bring the infrared sensor to market, and Lockheed Missiles and Space, United Technologies Optical Systems, Inc., and Lassen Research continue with their LIDAR laser system.



*An airplane, encountering microburst conditions, experiences headwind, windshear, and tailwind. Insufficient lift and energy in these conditions can cause a crash.*

### Technology Benefits

NASA and the FAA worked together to enable the aviation industry to produce systems that will provide advance warning of wind shear conditions. As a result of this collaborative effort, these systems

- > save lives not only in the U.S., but all over the world
- > avoid significant economic losses associated with accidents
- > represent new sensor designs and methodologies for certifying them
- > provide all aircraft which use predictive systems advance wind shear warning even if they are not operating in the vicinity of a large airport (many of which will be equipped with ground based systems for wind shear detection)

### Contact

For more information on this technology, please contact:

Dr. Roland Bowles  
NASA Langley Research Center  
Mail Stop 265  
Hampton, VA 23665-5225  
Phone: (804) 864-2035

# COMMERCIAL OPPORTUNITY PROGRAM (COOPPR)

The Langley Research Center's Commercial Opportunity Program implements NASA's management philosophy for enhancing utilization of government developed technology by the private sector. It does so by integrating the combined interests and talents of Langley management, technical staff, Offices of Technology Utilization and Applications, and Chief Counsel to match potential manufacturers with identified NASA proprietary technologies available for licensing and commercialization.

## 1 HOW THE PROGRAM WORKS

NASA identifies companies with experience and competence in related technologies; related manufacturing capabilities; track record in commercializing similar products; marketing organization; and stable financial condition. After attending a technical briefing, those companies interested in joining with NASA in a Joint Space Act Development Agreement, and the accompanying license agreement will be invited to submit proposals. Proposals should include a detailed plan for commercializing the proposed technology.

Thus, Langley's Commercial Opportunity Program leads to a working partnership between industry and NASA to transfer advanced and commercially valuable technology to the private sector for commercial product applications.

## 2 WHAT YOU NEED TO DO

Companies interested in attending a technical briefing on October 22, 1993 to learn more about the Self-Nulling Eddy-Current Device for flow detection should contact:

NASA Technology Applications Team  
Research Triangle Institute  
Attn: Molly O'Donovan Dix  
P.O. Box 12194  
Research Triangle Park, NC 27709  
TEL: (919) 541-5866  
FAX: (919) 541-6221

The briefing will be held at the NASA Langley Research Center in Hampton, Virginia, from 9:00 AM to 12:00 noon on October 22, 1993.

## 3 WHAT YOU NEED TO KNOW

NASA intends to commercialize this technology by patent license and/or Joint Space Act Development Agreement. Following the briefing, companies will be invited to submit a business proposal for a joint development and patent license agreement to Dr. George Helfrich, Langley Research Center, Mail Stop 143, Hampton, VA 23681-0001.

The business proposals will be reviewed by an in-house evaluation team of civil service NASA employees composed of a representative from the following: the Langley Instrument Research Division technical program, Langley Instrument Research Division management, the Technology Utilization and Applications Office, and the Office of Chief Counsel. The evaluation team may consult with outside advisors as required. Following selection, a *Federal Register* notice of intent to grant license will be published.

# SELF-NULLING EDDY-CURRENT FLAW DETECTION

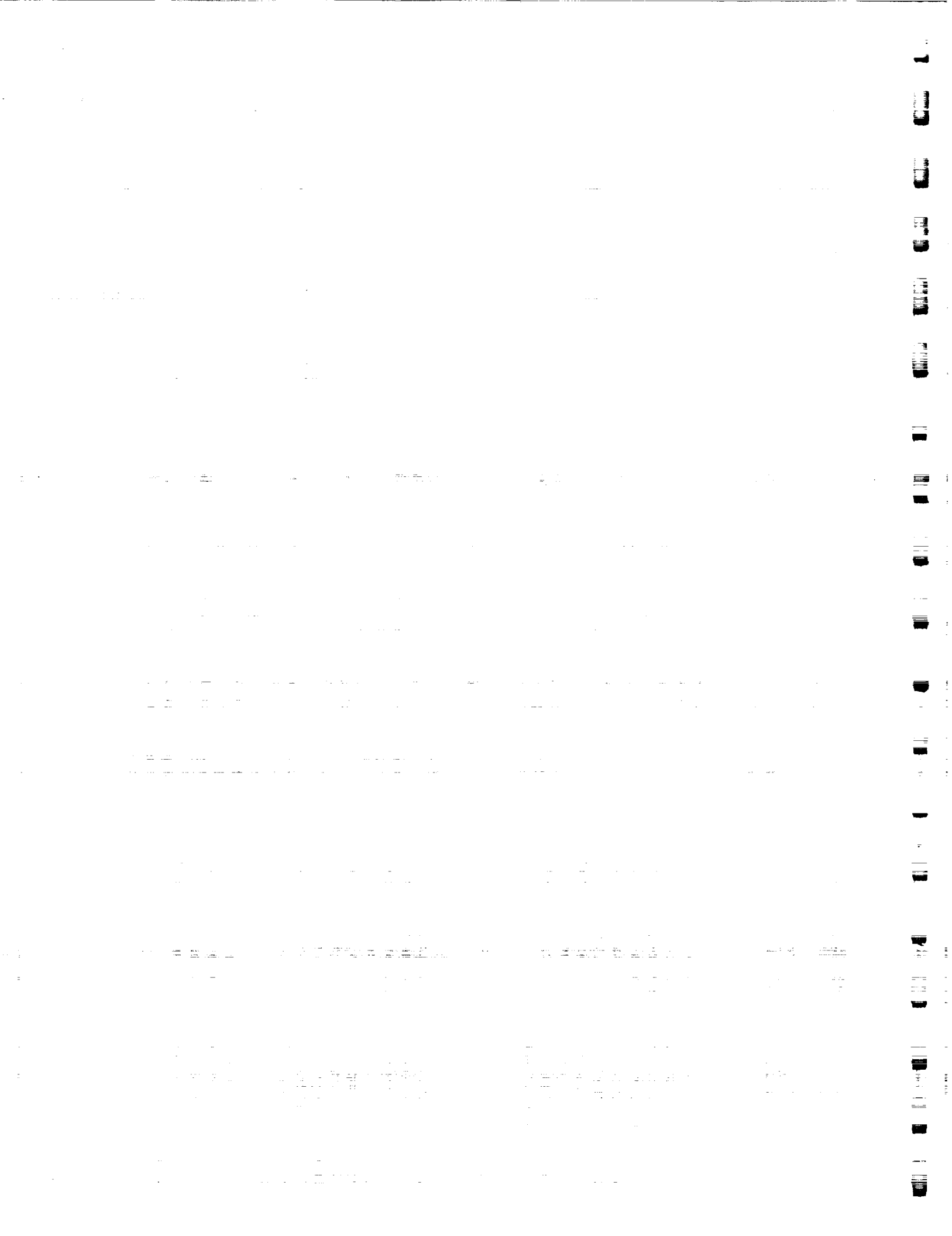
*Technical Briefing*  
*October 22, 1993*

*Team with NASA...*

*Commercial opportunities  
through technology utilization.*



National Aeronautics and  
Space Administration  
Langley Research Center  
Hampton, VA 23681



# EDDY-CURRENT FLAW DETECTION

The National Aeronautics and Space Administration (NASA) seeks to transfer into commercial application a Self-Nulling Eddy-Current Device for flaw detection. The Device, developed at NASA's Langley Research Center (LaRC), provides a clear indication of flaws in conductive materials with no need for prior calibration, balance circuitry, or reference standards. The Device requires little power, and is compact and lightweight, making it extremely portable. A Technical Briefing on October 22, 1993, will provide interested companies the opportunity to see the Device and to learn more about the technology and the commercialization opportunity being offered by NASA.

## TECHNOLOGY BACKGROUND

In an effort to enhance the airworthiness of America's aging commercial airline fleet, NASA's LaRC has investigated ways to advance conventional eddy-current techniques. Research in this area has resulted in the development of the Self-Nulling Eddy-Current Device, which is extremely sensitive to fatigue cracks in aluminum alloy plates. Large areas can be inspected quickly with unambiguous flaw indications displayed.

## INTELLECTUAL PROPERTY

The Technology is protected by a patent application. The patent application is titled "Flux Focusing Eddy-Current Probe and Method for Flaw Detection." The Langley Research Center Patent Office docket number is LAR-15046/15085.

## THE NASA DEVICE

The Device employs a unique driver-pickup coil configuration that produces a zero output voltage when unflawed material is inspected. In the presence of a fatigue crack, a large output voltage is recorded. Studies have shown flaw responses to be extremely stable and repeatable while lift-off errors are negligible. Prototype units have been constructed using nine-volt batteries as a power source and having a total weight of less than 1/2 pound.

The probe consists of a driving (primary) coil wound around a cylindrical ferromagnetic flux-focusing lens. In the interior of the lens, an AC voltmeter is connected to the leads of the high turn pickup (secondary) coil. The unique design feature of the probe is that the pickup coil is magnetically separated from the driving coil by the flux-focusing lens. The lens works to concentrate the field lines developed by the driving coil, thereby shielding the pickup coil from the effect of the driving coil.

The properties of the flux-focusing lens are such that directly under the lens a high magnetic flux density is produced. When the probe is placed above a conducting surface, a complete electromagnetic separation of the pickup coil from the driving coil can be achieved. The flux (able to pass around the flux-focusing lens when no test sample is present) is forced to interact with the conducting material under the probe during the test. The fields are attenuated as they pass through the material so that little field amplitude remains to reach the interior of the probe, resulting in a null signal.

When the probe is placed above a conducting sample, a high density eddy-current ring forms at the outer edge of the pickup coil. If there is a flaw in the region of the test sample where these eddy-currents are induced to flow, the current lines will be forced to alter their path and travel directly under the pickup coil. The magnetic field produced by the eddy-currents will be sensed by the pickup coil and a large output voltage will be recorded. The eddy-current path created at a crack tip has been shown to produce the largest field values, in many cases being larger than the in-air signal.

## BENEFITS

The unique operating characteristics of the Device enable test parts to be rapidly scanned, monitoring only the amplitude of the pickup coil signal. Flaw-sizing can be determined by the amplitude of the signal, with fatigue cracks of lengths comparable to the probe dimensions producing a signal amplitude of the order of the in-air signal. Some of the important features of the Self-Nulling Eddy-Current Device that have been confirmed at LaRC are:

- Detects fatigue crack in conducting materials
- Requires no calibration, reference standards, or balance circuitry (self-nulling)
- Insensitive to lift-off and probe wobble
- Provides clear, unambiguous flaw signal
- Requires minimal instrumentation
- Producible at low cost
- Portable (weighs less than 0.5 lb.)
- Requires minimal power (9 volt batteries)

## APPLICATIONS

The NASA Device is applicable to many markets. It can simplify nondestructive testing while increasing reliability of test results. Moreover, it is extremely effective at locating surface-breaking flaws in aluminum alloy plates for which it was originally designed. Based on this ability the vast number of aging aircraft provide a large market for the Device. Initial research results suggest that with slight modifications the Device will be effective at locating surface damage in a vast array of materials, including ferromagnetic steels. The Device's simple instrumentation suggests that it could be produced at a low cost, opening many other markets.



## **APPENDIX C**

**Technology Transfer Articles Published by Hazardous Materials  
Control Resources Institute (HMCRI) in *Focus* Newsletter**

THE UNIVERSITY OF CHICAGO



# Technology Transfer and Our Federal Laboratories

C. Gary Hughes

*The federal government invests more than \$5 billion each year on environmental research and development. Thirteen federal departments, institutions and agencies devote significant amounts of their budget to research, and this investment in environmental science represents a broad range of opportunity for those able to use or adapt the technology.*

*This article — the first of three that will appear between now and November — briefly describes the legislative history of federal technology transfer activities, discusses how to get started in the technology transfer process and describes a successful transfer.*

Technology transfer is the identification and adaptation of technology from federal laboratories to meet requirements of industry. Its results are not easily quantified because there are so many ways to make it happen, but technology transfer can result from

- reading about federal research in journals or conference proceedings,
- exchanging information directly with a government scientist,
- physical collaboration in either a federal lab or a company's research facility,
- executing licensing agreements for government-owned patents, or

- establishing a cooperative research and development agreement (CRDA).

The process of transferring technology is productive when it results in new revenues, jobs or businesses. And the best results come about when technology transfer is thought of as a "contact sport" — close encounters among champions from industry and the federal laboratory system. Anything less than real enthusiasm creates a risk of failure when the process becomes arduous.

## Legislative Background

The parade of legislation to unlock federal technology began in 1980 with the Stevenson-Wydler Technology Innovation Act. The Act was information-oriented; it required agencies to actively participate in technology transfer activities and established Offices of Research and Technology Application at the federal laboratories.

The Bayh-Dole Act of 1980 provided for ownership of intellectual property for universities and not-for-profit institutions that conducted research under federal contracts or grants. It also allowed, for the first time, government-owned and operated laboratories to license technology to commercial entities.

The 1984 Small Business Innovation Act laid the groundwork for the now familiar Small Business Innovation Research Program (SBIRP), which gives small businesses the opportunity to

work on agency mission-oriented research in return for at least partial funding and certain rights to the results of the work.

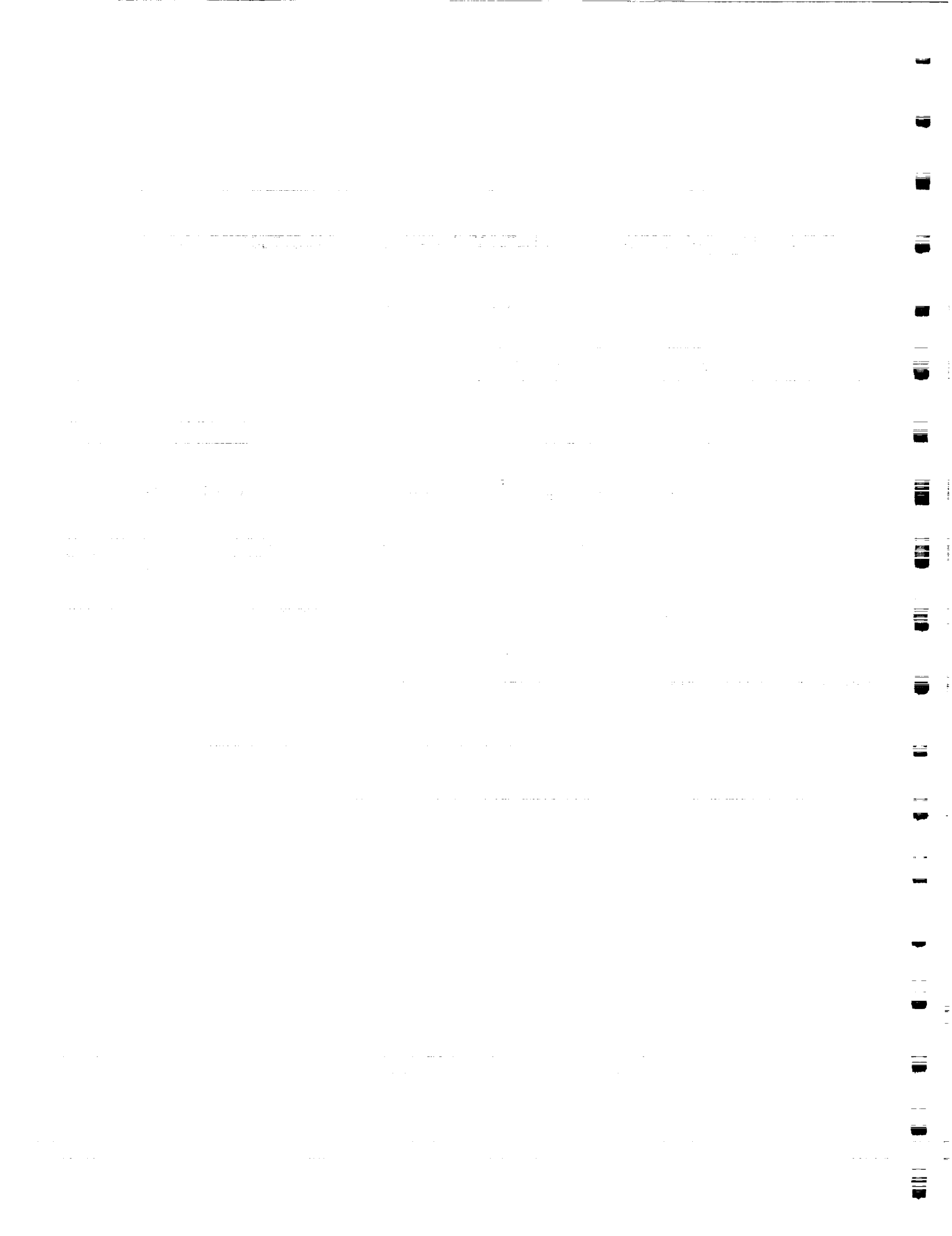
The Cooperative Research Act of 1984 cleared the way for the formation of industry consortia that could work on solving common problems without the threat of anti-trust action.

The Trademark Clarification Act of 1984 improved the technology transfer odds: it allowed inventors to receive royalties on their patents, addressed the transfer of technology from government owned/contractor operated laboratories and made possible the exclusive licensing of patents to commercial businesses.

The Federal Technology Transfer Act of 1986 (FTTA) created broad authorities and established technology transfer mandates for the federal laboratories, and their scientists and engineers. It also created the Federal Laboratory Consortium and provided the authority to establish — down to the lab management level — CRDAs between industry and the federal laboratories (More than 500 CRDAs were implemented in 1992).

Additional laws and executive orders have enhanced the environment for matching government technology with industry needs:

- Executive Orders 1251 and 126618,
- Omnibus Trade and Competitiveness Act,
- National Institute of Standards and Technology Transfer Act,
- National Competitiveness Technology Transfer Act,



- Water Resources Act,
- Defense Authorization Act, and
- Defense Conversion, Reinvestment, and Transition Assistance Act of Fiscal Year 1993, known as the Technology Reinvestment Program (TRP).

That's a barrel full of legislation, and it shows that the federal government is very serious about transferring technology. Most recently, through the TRP and the expected National Competitiveness Act of 1993, impressive amounts of budget are being allocated to make the process quicker and more efficient, and to encourage more laboratory and industry involvement.

#### Getting Started

Companies are increasingly less able to carry out the R&D necessary to survive and grow in their industry. The key to tapping into the research available through federal technology transfer is knowing whom to contact.

Company researchers may learn of relevant work through attendance at professional meetings, workshops or conferences such as the National technologies Initiatives of last year. And the federal government funds a number of technology transfer "facilitators." There is a plethora of newsletters and a trade publication that publicize developments at major labs. The federal agencies themselves publicize available technology through a variety of printed or on-line materials.

The next two articles in this series will go into more detail about environmental R&D programs at federal agencies, federally funded transfer organizations and contact points at federal laboratories. In the interim, an excellent resource is *The 1993 CRADA Handbook*, Technology Publishing Group, Washington, DC; phone 202-966-9610, FAX 202-363-6929.

#### Tech Transfer Example

**Gas-enhanced woodstove:** The underlying technology for the gas-enhanced woodstove was

developed at EPA's Air & Energy Engineering Research Laboratory (AEERL) in Research Triangle Park, NC. AEERL scientists developed a technique for dramatically reducing particulate, volatile organic and carbon monoxide emissions from conventional woodstoves. The method employs a secondary combustion zone fired by a very small gas-fueled pilot flame.

After publicizing the innovation, EPA discussed transferring the technology with several interested manufacturers. Aladdin Steel Products, Inc. was selected (after appropriate notice of intent and a 60-day response period) as exclusive licensee for the process.

Through a CRDA executed in September, 1992, Aladdin will work with AEERL staff to commercialize the process and offer it as an option in their line of woodstoves.

**C. Gary Hughes** is a research engineer with the NASA Technology Applications Team at Research Triangle Institute (RTI), PO Box 12194, Research Triangle Park, NC 27709-2194; phone 919-541-7202, FAX 919-541-6221.



# TECHNOLOGY TRANSFER AND OUR FEDERAL LABORATORIES

C. Gary Hughes

This article is the second of three to address the opportunities for making use of government funded research in the environmental field. In the July issue of FOCUS we reviewed the concept of technology transfer, examined Federal legislation enabling the government to work closely with industry, and provided a starting point for the search for useful Federal research.

In this article, we will present contact points within the government and other technology transfer organizations. This compilation is by no means exhaustive, but it does cover important key points of entry. By starting with these contacts, one can easily access a wealth of information about the Federal government's environmental R&D resources.

Our government is investing more than \$5 billion in environmental research. The agencies and departments that are spending large sums on environmental R&D do so to advance their missions. The breakdown shown here summarizes the environmental R&D budget by agency for fiscal year 1992. Opportunities for accessing commercially viable technologies exist with each of these organizations. Many of the R&D programs are dealing with hazardous waste issues, including waste treatment and site mitigation.

Also, relevant processes are occasionally discovered during programs that are initially designed to tackle problems unrelated to hazardous waste. For example, at NASA's Lewis Research Center in Cleveland, scientists discovered that a polymer being investigated as an ion exchange material for space use had the ability to remove heavy metal ions from waste water, even in the presence of calcium. This innovation has recently been published and represents an opportunity for polymer manufacturers who serve the hazardous waste treatment industry.

The challenge for companies who want to access new technologies is to know where to go for timely and quality information. There are basically three sources of information: individual laboratory contacts, national technology transfer network and outreach mechanisms such as publications, trade shows and conferences.

The first two will be covered in this article. The last will be addressed in the next article, along with some case studies of how the system works for those who pursue Federal technologies.

## Federal Agency Information

Individual laboratories may be contacted through their Offices of Research and Technology Applications. There are literally hundreds of these offices, some of which are known by other names (such as Office of Industrial Technology, Technology Utilization Office and Office of Technology Transfer). Space limitations prevent us from listing all of them. However, the listing below provides information on the main contacts at a number of the agencies mentioned above. These contacts will provide a wealth of information on agency specific programs, individual laboratory contacts, and a summary of technologies currently available for commercialization.

**National Aeronautics and Space Administration**  
Office of Advanced Concepts and Technology  
Mr. Frank Penaranda  
Manager, Technology Transfer Commercial Development and Technology Transfer Division  
Code CU  
Washington, D.C. 20546-0001  
(202) 358-0723

**Department of Energy**  
Mr. Roger Lewis, Director  
Office of Technology Utilization  
Forrestal Building  
ST-40  
1000 Independence Avenue  
Washington, D.C. 20585  
(202) 586-5388

**U.S. Army**  
Mr. Clifford Lanham  
Manager, Army Domestic Technology Transfer Program (ADTTP)  
U.S. Army Research Laboratory  
ATTN: AMSRL-CP-TT  
(C. Lanham)  
2800 Powder Mill Road  
Adelphi, MD 20783-1145  
(301) 394-4210

**U.S. Navy**  
Dr. Ronald M. Culpepper  
Office of Naval Technology  
800 N. Quincy Street (Code 26)  
Arlington, VA 22217-5660  
(703) 696-4448  
Fax (703) 696-5993

**U.S. Air Force**  
Dr. Charles F. Chatlynn  
Manager, Domestic Technology Transfer Program  
1500 Air Force Pentagon  
Washington, D.C. 20330-1500  
(703) 695-3891

**National Science Foundation**  
Ms. Nora Sabadell  
Program Director  
Hazardous Waste and Mitigation  
1800 G Street NW  
Room 1132  
Washington, D.C. 20550  
(202) 357-9780

**Department of the Interior**  
U.S. Geological Survey  
Dr. Anton Inderbitzen  
Deputy Assistant Director for Research  
MS 104 National Center  
12201 Sunrise Valley Drive  
Reston, VA 22092  
(703) 648-4450

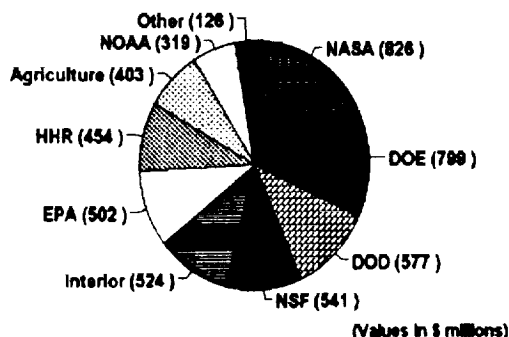
**U.S. Environmental Protection Agency**  
Mr. Larry Fradkin  
Federal Technology Transfer Coordinator  
Office of Research and Development  
Environmental Research Center  
26 West Martin Luther King Drive  
Cincinnati, OH 45268  
(513) 569-7960  
Fax (513) 569-7132

## National Technology Transfer Network

The primary elements of the national technology transfer network are the Federal Laboratory Consortium for Technology Transfer (FLC), National Technology Transfer Center (NTTC), and the Regional Technology Transfer Centers (RTTCs). In addition, NASA provides for a Technology Applications Team to work with the NASA field centers.

The FLC was organized in 1974 to provide a central technology transfer organization for all of the Federal laboratories. The FLC was officially charged in the Federal Technology Transfer Act of 1986 to be

**Federal Funding for Environmental R&D by Agency (FY92)**  
**\$5.07 Billion Total Funding**



Adapted from:  
*Environmental Research and Development: Strengthening the Federal Infrastructure*,  
Carnegie Commission on Science, Technology and Government, 1992.

1. The first part of the document is a list of the names of the persons who were present at the meeting.

2. The second part of the document is a list of the names of the persons who were absent from the meeting.

3. The third part of the document is a list of the names of the persons who were present at the meeting.

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the driving force behind the Federal laboratory technology transfer efforts. The FLC network deals with individual companies, small and large, who are seeking Federal laboratory resources to solve specific problems. They also provide a forum for the laboratory representatives where technology transfer methods, barriers and management issues can be discussed and improved.

The NTTC and the six RTTCs are funded through NASA. The NTTC was mandated by Congress in 1991 to become a national resource for Federal technology transfer designed to interface with all of the Federal laboratories. In order to provide a central clearinghouse for Federal technology transfer efforts, the NTTC has created links to the RTTCs, the Federal agencies and their laboratories, and industry. In addition, the NTTC conducts outreach activities, collects and organizes diverse Federal R&D information databases, and provides training and education services in technology transfer.

The RTTCs are located and serve the public in the six FLC Regions. They were also recently (1992) organized from the former system of Industrial Application Centers. The RTTCs are designed to provide direct interfaces between individual companies and Federal laboratories in their regions. They also work closely with state and municipal technology development and deployment programs. RTTCs provide information services, technical services (for example technology assessments), and communication services. Operated by the private sector, the RTTCs derive funding from NASA, other government programs, and from fees charged for some services.

NASA also funds a Technology Applications Team (TATeam) which is located at and operated by the Research Triangle Institute in North Carolina. The TATeam mission is national in scope and deals primarily with technologies developed at the nine NASA field centers. Concentrating on national industrial priority issues, the TATeam works closely with the Technology Utilization Offices at the field centers to develop commercialization opportunities involving private sector and NASA resources. Assisting with establishing dual use projects, promoting patent license opportunities and helping to find solutions to critical technology problems all fall within the TATeam's scope. Contact information for these organizations is given below.

**Federal Laboratory Consortium**  
The FLC Administrator  
224 W. Washington, Suite 3  
P.O. Box 545  
Sequim, WA 98382-0545  
(206) 683-1005  
Fax (206) 683-6654

**National Technology Transfer Center**  
Wheeling Jesuit College  
316 Washington Ave.  
Wheeling, WV 26003  
(800) 678-6882 (toll free)  
Fax (304) 243-2463

**Far West RTTC**  
Technology Transfer Center  
University of Southern California  
3716 S. Hope St., Suite 200  
Los Angeles, CA 90001  
(800) 872-7477 (national)  
(800) 642-2872 (CA only)  
(213) 743-6132  
Fax (213) 746-9043  
Mr. Robert L. Stark, Dir.

**Mid-Atlantic RTTC**  
Mid-Atlantic Technology Applications Center  
University of Pittsburgh  
823 William Pitt Union  
Pittsburgh, PA 15260  
(800) 257-2725  
(412) 648-7000  
Fax (412) 648-7003  
Ms. Lani S. Hummel, Dir.

**Mid-Continent RTTC**  
Commercial Technology Services  
Texas A&M University  
237 Wisenbaker Engineering Research Center  
College Station, TX 77843  
(409) 845-8762  
Mr. Gary Sera, Dir.

**Mid-West RTTC**  
Great Lakes Industrial Technology Center  
25000 Great Northern

Corporate Center  
Cleveland, OH 44070-5310  
(216) 734-0094  
Fax (216) 734-0686  
Dr. Joseph W. Ray, Dir.

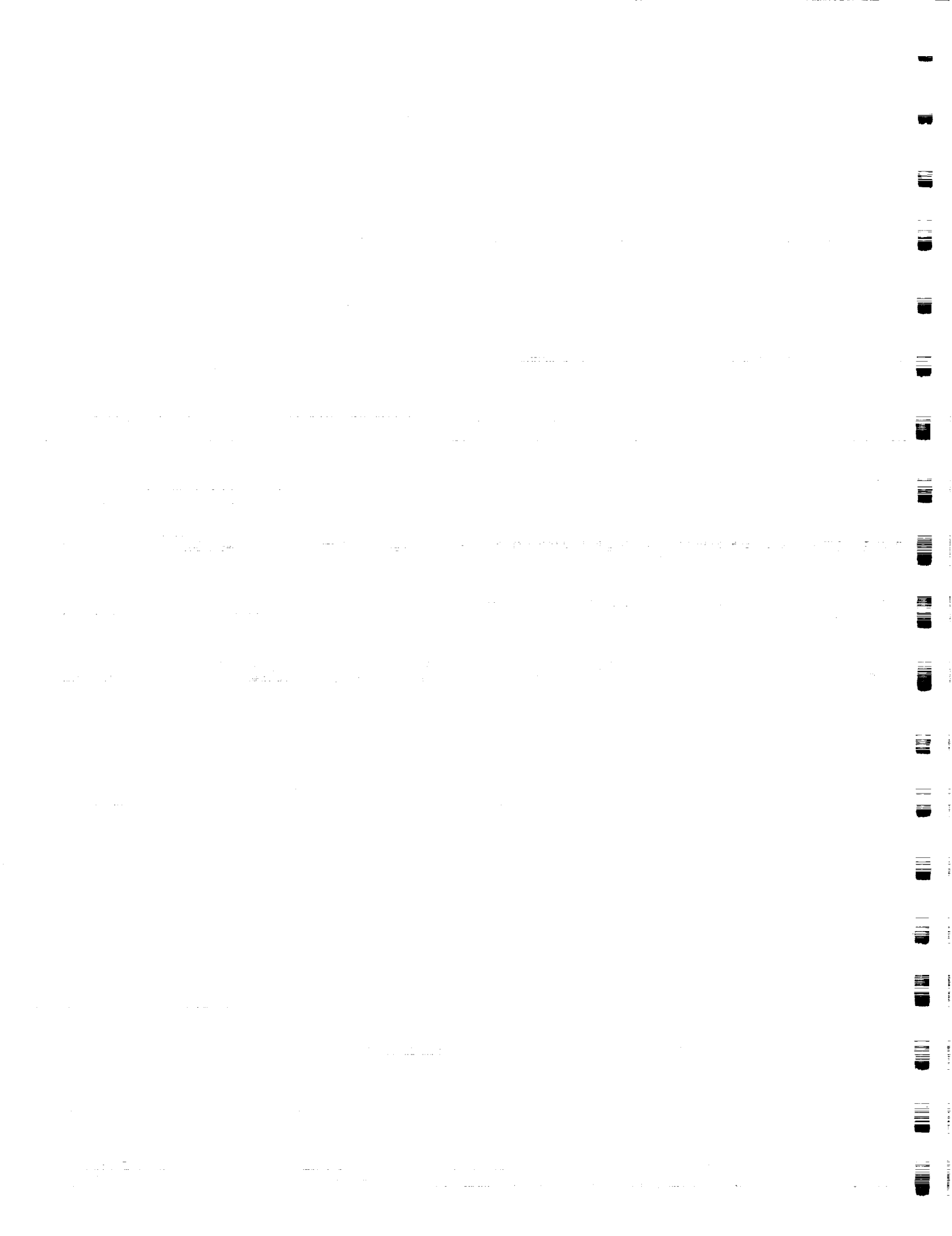
**Northeast RTTC**  
Center for Technology Commercialization  
Massachusetts Technology Park  
100 North Drive  
Westborough, MA 01581  
(508) 870-0042  
Fax (508) 366-0101  
Dr. William Gasko, Dir.

**Southeast RTTC**  
Southern Technology Applications Center  
University of Florida  
Box 24, One Progress Blvd.  
Alachua, FL 32615  
(800) 225-0308 (national)  
(800) 354-4832 (FL only)  
(904) 462-3913  
Fax (904) 462-3898  
Mr. J. R. Thornton, Dir.

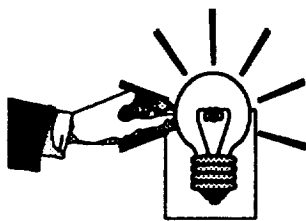
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One last tip: give ample thought to your objectives before you begin. You will get the best guidance when dealing with specifics rather than generalities.

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# TECHNOLOGY TRANSFER *and* Our Federal Laboratories

C. Gary Hughes, Contributing Editor

*This is the final article in a series of three describing opportunities for making use of government funded research in the environmental field. The previous articles (FOCUS, July and September) discussed the idea of technology transfer, the enabling legislation, how to get the process started, and the contacts for technology transfer in the government agencies and in government-sponsored transfer infrastructure. This article provides more detail about research information sources in federal agencies, and summarizes legislation that may have an important impact on the relationship between government agencies and industry.*

## U.S. Environmental Protection Agency

EPA's body of research is divided among the 12 laboratories of the agency's Office of Research and development (ORD) and the laboratories operated by EPA's program offices (such as the Office of Mobile Sources in Ann Arbor, Mich.). ORD's mission is to expand the scientific knowledge base and to provide the foundation for the regulatory function of the agency. Much of the work done at the ORD laboratories is applied research. The program offices tend to have more specialized laboratories and to work more closely with the "customer." Opportunities exist for technology transfer in both sides of the house. The most notable feature of EPA's research is the breadth of coverage. Literally every field is represented, from health effects to water quality, from stationary sources to pollution prevention technologies.

EPA publishes an enormous amount of material describing their research programs, technology transfer mechanisms, information clearinghouses, databases, etc. A good source for identifying these various resources is the *ACCESS EPA* directory (EPA/220-B-92-014; available through the National Technical Information Service (NTIS), 703-487-4650). If you are able to access electronic bulletin boards (BBS), you can search *ACCESS EPA* and other information resources through the EPA On-Line Library (919-541-4642). Another EPA BBS of interest is operated by ORD in Cincinnati at 513-569-7610. The ORD BBS allows you to leave and accept messages, search the ORD bibliographical database, order publications, read the latest bulletins and news items, participate in conferences, and upload or download files.

## National Aeronautics and Space Administration

The popular press on NASA's participation in environmental R&D focuses on the space-based mission using the Earth Observing System (EOS). Goddard Space Flight Center in Greenbelt, Maryland is responsible for operation of EOS, which makes use of remote sensing satellites to study such global issues as volcanism, climatology and oceanography. A complimentary program designed to help companies to build businesses around this space-based science platform is the Earth Observation Commercialization Applications Program (EOCAP). EOCAP is operated out of Stennis Space Center in Mississippi; contact program manager Hugh Carr (601-688-2466) for information.

NASA's terrestrial-based R&D covers a broad range of relevant pollution prevention, waste treatment and air and water quality issues of direct interest to the environmental engineering community. Technology transfer opportunities may be investigated through the various Field Center Technology Utilization Offices. Examples of other NASA programs that have developed and make available environmental technologies are:

☐ Ames Research Center, Moffett Field, CA. Contact Geoff Lee

(415-604-4044). Information is available on air and water recycling, life support systems, indoor air quality and solid waste treatment.

☐ Kennedy Space Center, FL. Contact Jim Aliberti (407-867-3017). Information is available on hazardous emissions and contamination monitoring, biospherics, closed life support systems, geographic information systems, air quality monitoring, chlorofluorocarbon substitutes (materials and methods) and water treatment.

☐ Johnson Space Center, Houston, TX. Contact Dick Ramsell (713-483-0381). Information available on real time air quality monitoring, toxicology, microbiology and robotic manipulators.

## Department of Energy

Among federal agencies, DOE has the largest terrestrial-based budget for environmental R&D. Sporting nine multiprogram laboratories and 12 large single-program labs, DOE carries out a variety of environmental research activities. The DOE labs all have technology transfer missions. The main tech transfer contacts are the offices of Research and Technology Applications at each of the major laboratories. A good source of laboratory overviews, contact information, etc. is *Technology Transfer 92/93* (DOE/ST-0005P DE93003623), available through NTIS (703-487-4650).

Among the more notable DOE environmental R&D programs with technology transfer possibilities are:

- ☐ Enzyme treatment for hazardous wastes (Argonne National Laboratory),
- ☐ Soil reclamation and recovery (Brookhaven National Laboratory),
- ☐ Microbial enhanced oil recovery (Idaho National Engineering Laboratory),
- ☐ Flue gas scrubbing technology (Lawrence Berkely Laboratory),
- ☐ Oil recovery techniques (Los Alamos National Laboratory),
- ☐ Destruction of toxic organics in groundwater (National Renewable Energy Laboratory), and
- ☐ PCB destruction using chemical dehalogenation (Pacific Northwest Laboratory).

DOE is also a major player in programs such as clean coal, global climate change and energy lab hazardous waste cleanup. With the ongoing post-Cold war transformation of weapons laboratories and the increased emphasis on technology transfer, DOE should be an increasingly more important source of new environmental technologies.

## Other Federal Agencies

The remaining three of the top six funding agencies in environmental R&D include the Department of Defense (DOD), the National Science Foundation and the Department of Interior.

Most of DOD's nearly \$600 million in funding is handled by the Navy's Office of Naval Research (ONR). About \$500 million is allocated by ONR to grant programs for universities (and some nonprofit companies) to perform primarily oceanographic R&D.

One of the most prolific DOD producers of new technology is the Ballistic Missile Defense Organization (BMDO), formerly known as the Strategic Defense Initiative Organization. BMDO holds periodic technology application reviews to bring industry experts together with BMDO scientists. Each briefing examines potential technology transfer opportunities in particular industries or application areas. A briefing is scheduled for early December 1993 to discuss environmental technologies such as waste treatment methods and innovative sensors. Contact Dick Montanarelli (703-693-1671) for additional information.

The National Science Foundation operates a comprehensive grants program, including more than \$500 million for universities and other research institutes for environmental R&D.

The Department of Interior commits most of its \$524 million to two programs: The U.S. Geological Survey and the Fish and Wildlife Service.

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### Envirotech

The global environmental management market is expected to grow to as much as \$300 billion by the year 2000. In order for U.S. companies to compete in the international market, many issues need to be settled at home. Congress and the Administration want to help industry with new technology development. The Environmental technology Initiative (Envirotech), Senate Bill 978, is designed to address this general issue. If passed, the legislation will:

- ✓ Require government to set up an interagency panel to formulate a national strategy for environmental technologies,
- ✓ Establish an environmental innovation research program similar to the Small Business Innovation Research program,
- ✓ Provide a seedbed to help small and medium size companies as they risk resources to develop new technologies, and
- ✓ Create an Environmental technologies Institute and an Environmental Technology Clearinghouse within EPA to centralize the federal government's environmental technology interactions with industry.

### Conclusion

Federal government R&D represents a significant investment of resources. The path between technologies that result from these investments and the commercial market can be easy or arduous, depending on the

technology transfer mechanism. As noted in an earlier article, it is imperative to define specific technology goals before you go shopping; generic searches turn up generic results, with very little real value. With the information provided in this series of articles, gathering the information should be easier; the sources are generally quick to respond with ample information.

Direct contact through the mail or by phone is a good start, but the experience of the NASA Technology Application Team suggests that you must eventually see the technologies and researchers in person. Opportunities are plentiful, and include laboratory open houses, conferences and workshops. National conferences such as Superfund XIV offer good opportunities to see the technologies and to meet the researchers in person. Technology transfer opportunities are becoming more plentiful and the mechanisms more polished. Knowing what you want is of paramount importance; once you've determined that, identify the potential resources and go after them with persistence: chances are, your efforts will be rewarded.

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